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Spatiotemporal Analyses of Child Pedestrian-Vehicle Incidents Occurring during School-Commuting Hours in Metro Atlanta from 2000 to 2007

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SPATIOTEMPORAL ANALYSES OF CHILD PEDESTRIAN-VEHICLE INCIDENTS OCCURRING DURING SCHOOL-COMMUTING HOURS IN METRO ATLANTA FROM 2000 TO 2007

by

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Under the Direction of Dr. Dajun Dai

ABSTRACT

From 2000 to 2007, the five core county area of Metropolitan Atlanta (Fulton, Dekalb, Clayton, Cobb and Gwinnett) experienced 1,871 incidents involving child pedestrians. Nearly one-third of these incidents occurred during school-commuting hours. This study examines the geospatial locations of these incidents, with regards to the location of all 647 public schools within the study area. A GIS is used to analyze the spatiotemporal arrangement of these incidents in order to find risk factors and patterns in the data. Aspects of the built environment are then considered in areas with higher frequencies of child pedestrian-vehicle incidents. A walkability assessment is conducted to assess risk factors involved in the increased incident frequencies in an area of Stone Mountain. A correlation with the location of parks, recreation centers and other destinations are found. Improvements and installation of crosswalks are suggested in order to improve safety and walkability of child pedestrians in these areas.

INDEX WORDS: GIS, Child pedestrian-vehicle incidents, Built environment, Metro Atlanta

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1 Introduction

Walking is the most natural and healthy means of transportation that people can use. However, in today's fast-pace lifestyle, walking can prove to be a dangerous activity if the conditions are not suitable. Unfortunately, child pedestrians are at a great risk of being injured or even killed while walking in unsafe and high traffic areas. Due to the fact that many children walk to school, this puts them at an increased risk of being involved in pedestrian-vehicle incidents.

In Metropolitan Atlanta there are 647 public schools, many are located within reasonable walking distance from the homes of many school-aged children. Without proper safety features in the built environment, these children are at risk of being seriously injured or killed. It is assumed that the school commute, or even the commute to the bus stop, can pose as a threat to the safety of school children. Thus, the focus of this study places emphasis on the proximity of schools and child pedestrian-vehicle incidents.

Between 2000 and 2007 alone, 1,871 incidents involving child pedestrians occurred in Metropolitan Atlanta. The goal of this research is to explore the locations of the 488 incidents involving children on their school-commute and find possible explanations as to why these incidents occurred, with regards to the location of schools and other destinations in these areas. Findings from this research will help to reduce the occurrence of child pedestrian-vehicle incidents, improve safety for school children and create a more walkable environment for all pedestrians in Metropolitan Atlanta.

2 Literature Review

Although walking is a natural and healthy activity, many people miss out on the opportunity to walk on a daily basis due to today's busy lifestyle and the existence of readily available, faster forms of transportation. According to Kweon et. al (2009) and Clifton (2009), there has been a decrease in the amount of pedestrian-vehicle incidents over the past few decades, but this is likely due to a decrease in walking. Walking is also avoided in some areas where safety is a concern. Safety is often a concern for parents and in some cases, even if students live well-within walking distance from school, they often opt out of walking, due to the concerns of their parents. Connelly et. al (1998) found that most child pedestrian-vehicle incidents occur during hours that children walk to-and-from school and involve children ages five to nine.

In order to increase children's daily physical activity, walking to school can be encouraged as a means by which children can incorporate exercise into their daily routine. However, it is assumed that changes need to first be made to the built environment to improve the safety and walkability of school areas for children. According to Weir (2009), pedestrian-centered development should be a must in planning. Clifton (2007) stated that improving walking conditions for pedestrians involves identifying the relationship between pedestrians and the built environment. If planners are aware of the routes in which school children are walking to school, the features of the built environment along these routes can be modified in order to improve safety.

Unfortunately, many children who do walk to school on a daily basis are often at risk because their health and safety have been overlooked in the design of the built environment around their route to school. In a study by Zhu et. al (2008), "schools with higher poverty rates were located closer to their students' homes but showed much worse street environments" (Zhu et. al, 2008, p. 289). Therefore, monitoring the safety and walkability of neighborhoods in low-income areas is a must. Some efforts have been made to do just that: in some areas, including some cities in California, Florida and Georgia, programs such as the Safe Routes to School Program have been implemented in lower income neighborhoods (Boarnet, 2005, p. 135). According to Watson et. al, (2008), these programs allocate federal funding for construction projects to improve child pedestrian safety in urban and suburban areas. The Safe Routes to School programs aim at increasing physical activity for school children and communities as a whole, as well as, increasing social capital. The focus of these projects is to improve the walkability of neighborhoods by improving intersections, creating crosswalks and improving sidewalks, which are all features of the built environment.

The built environment encompasses various aspects of the surrounding environment such as the street network, sidewalks, signage and lighting. The built environment of an area affects the type of development and the amount of traffic flow in that area. Dissanayake (2009) stated that land use and built environment features can be a determinant of pedestrian casualty because it affects the flow of traffic and the safety of pedestrians. Schneider et. al (2004) also suggests that environmental factors and land use patterns play a role in increasing the frequency of pedestrian-vehicle incidents.

Although pedestrians can be found in any environment, there are some areas where pedestrians are more at-risk of being injured in an accident. In an analysis by LaScala et. al (2003), results suggest that, low-income communities in California with higher traffic flows and higher frequency of unemployment experienced higher frequencies of child pedestrian-vehicle incidents. In communities such as these, children have no other option but to walk to school, despite the dangerous conditions in their neighborhoods. Other characteristics of these at-risk neighborhoods include higher volumes of traffic, higher speed limits, wide roads, few crosswalks, and poor lighting and signage. According to Weir et. al (2009), traffic volume is considered to be a primary risk factor of vehicle-pedestrian collisions.

Crosswalks are a simple addition to the built environment that can improve the safety of pedestrians. In a study by Al-Ghamdi (2002), 77.12% of pedestrians involved in pedestrian-vehicle incidents were hit at areas where there weren't any crosswalks. In a study by Gardner (2004), intersections with crosswalks were deemed "50% safer" due to a reduction in pedestrian-vehicle incidents in these intersections. However, merely painting lines on the street to create a crosswalk does not improve safety for pedestrians if the appropriate signage or lighting is not used. Also, crosswalks cannot improve safety of pedestrians if the pedestrians are not willing to use them, for reasons such as placing them in "inconvenient" locations. Al-Ghamdi (2002) found that 29% of pedestrian-vehicle incidents in one study occurred where a crosswalk was within close proximity to the scene of the accident. Marking a crosswalk may improve safety, but it also gives pedestrians a false sense of security (Leden et. al, 2006).

The majority of the literature on pedestrian-vehicle incidents supports the finding that lighting conditions play a role in incidents. In the study by Al-Ghamdi, more incidents overall occurred during the day, but the cause of incidents occurring at night were due to inadequate lighting conditions. Although most pedestrian-vehicle incidents occur during daylight hours, mainly due to the fact that there are more daylight hours in which drivers use the roadways, incidents occurring at night most often occur due to inadequate lighting conditions. With regards to inadequate lighting, improving lighting conditions in pedestrian-frequented areas, especially crosswalks, is a must.

With regards to weather conditions influencing pedestrian-vehicle frequencies, much of the literature on pedestrian-vehicle incidents states that during inclement weather, there are typically fewer pedestrians on the roadways. It is also stated in a majority of the literature that inclement weather often leads to slower overall speeds for drivers, leading to fewer pedestrian-vehicle incidents overall. Inclement weather causes people to drive with caution, which leads to fewer crashes (Kim et. al, 2008).

A reduction in the speed limit in surrounding pedestrian-frequented areas is a must to improve safety. When the speed limit is reduced, drivers are more likely to slow or stop for pedestrians (Gardner, 2004). This is certainly true in areas surrounding schools in order to avoid child pedestrian-vehicle incidents. Speeds should be reduced during school hours, as well as, school-commuting hours (Abdel-Aty et. al, 2007).

Areas that support pedestrians and are connected to public transit experience more pedestrian-vehicle incidents, but these incidents tend to be less severe because of slower speeds (Clifton, 2009). Conversely, higher speeds on larger roadways tend to lead to more severe injuries and fatalities (Kim et. al, 2008). According to a study of New Zealand children ages five to 15 by Roberts et. al (1995), children are six times as likely to be struck by a vehicle on roads with higher volumes of traffic. Also, according to Rosen et. al (2009), city areas should maintain lower posted speed limits where most pedestrian-vehicle incidents occur. These examples suggest that a reduction in the speed limit around schools is needed in order to improve safety and walking conditions for child pedestrians.

According to Dissanayake et. al (2009), children are “one of the most vulnerable non-motorized traffic groups” (Dissanayake et. al, 2009, p. 1017). Generally, children aren’t capable of making the decisions necessary to successfully cross the street safely, due to cognitive development being a gradual process (Connelly et. al, 1998). The peak age for child pedestrian-vehicle incidents is age seven because seven-year-olds begin taking trips on their own, despite their lack of skills and cognitive abilities at this age (Assailly, 1997).

Children are often considered to be at-fault for pedestrian-vehicle incidents due to impulsiveness and developmental issues in cognitive functioning. Roberts et. al (1994), examined a case where a New Zealand girl was struck by a van and killed on her way from school. During a court session, the judge and jury sided with the driver of the truck who claimed to have been driving 40 kph in a 50 kph zone. The child was blamed for the accident without giving any consideration to the child's Socioeconomic Status, the location of the school, the surrounding speed limits or whether there was a suitable street crossing located nearby (Roberts et. al, 1994). In the case of child pedestrian-vehicle incidents, other factors need to be examined other than simply blaming the child for being young and inexperienced.

With regards to populations of children at-risk for pedestrian-vehicle incidents, as previously mentioned, children living in lower-income areas, with no access to other modes of transportation are often considered at-risk. In a study examining wards within Devon County, UK, Hewson (2005) found that SES does play a role in determining the safety and likelihood of child pedestrian-vehicle incidents in some areas where children do not have access to other modes of transportation.

A majority of the literature examines the differences in injury severity and fatality frequencies depending on the age of the pedestrian involved in an accident. According to Assailly (1997), in Europe, five to nine year olds, and the elderly are commonly involved in pedestrian-vehicle crashes. Due to a variety of factors, children often survive pedestrian-vehicle incidents. In a study by Al-Ghamdi (2002), 42.63% of pedestrians involved in pedestrian-vehicle incidents were 15 years or younger and there was a 27.57% fatality rate. According to a study of individuals injured in pedestrian-vehicle incidents in L.A. County, by Peng et. al (1999), the highest mortality rate was observed in individuals older than the age of 65, followed by adults ages 15 to 65, with the lowest mortality rate being observed by children under 15 years of age.

Although the occurrence of child pedestrian-vehicle incidents is often inevitable, the literature supports the finding that efforts to educate students and parents is ongoing in many schools across the US. Boarnet (2005) stated that it is necessary for there to be engineering changes to the built environment, along with educational efforts for children and parents in order to increase children's physical activity. According to Watson et. al (2008), the Safe Routes to School Programs also provide funding for educational programs for parents of school age children.

Some of the literature found that middle school-aged children are often involved in pedestrian-vehicle incidents and LaScala et. al (2003) suggests that education intervention for parents of middle schoolers is imperative. Ultimately, children need to be taught these behaviors by following examples and this is where the role of the parents or guardians is crucial. Parents who model safe-crossing habits are the best example for children to follow (Morrongiello et. al, 2009).

3 Objectives and Hypotheses

The objectives of this study are to evaluate the spatial distribution of child pedestrian-vehicle incidents within the five-county study area in Metro Atlanta and examine the possible correlation with the location of schools, parks and other destinations, with regards to the time of day that school children will be commuting to-and-from schools. This study hopes to find risk factors that the incidents can be attributed to and further uncover any trends in the data that can help planning, transportation or public health officials to improve walking conditions for all pedestrians in Metro Atlanta.

The first hypothesis in this study is that incidents occurring within close proximity to schools will make up a relatively-high percentage of overall incident frequencies. The second hypothesis is that these incidents will occur during “school-commuting” hours, or the hours in which students walk to-and-from school. The third hypothesis is that the immediate area around these schools contains few, if any, of these incidents due to the fact that this area typically has lower posted speed limits, more crosswalks, crossing guards and more adults present to monitor child behavior and safety in this area. The fourth hypothesis is that, based on previous findings from other studies, the areas with resulting clusters of incidents will occur in low-income, densely-populated, high-traffic areas. These areas with higher frequencies of incidents will be found in order to uncover focus areas where significant improvements need to be made to improve safety. The built environment will be examined to determine what changes need to be made to improve safety and walkability. Spatiotemporal patterns in the data will be examined to find trends.

This study uses exploratory data and assumes that it will aid in uncovering any areas of the built environment that are in-need of modification. Findings from this study can aid in devising preventative measures to protect child pedestrians in Metropolitan Atlanta. Also, it is assumed that this data will help to find other risk factors that cannot be remedied simply through modifying the built environment.

The assumptions in this study are that child pedestrian-vehicle incidents occurring during what is considered to be school-commuting hours (6 to 9 am and 2 to 5 pm) will constitute a large percentage of child pedestrian-vehicle incidents around school locations in Metropolitan

Atlanta's five core counties. It is also assumed that there will not be as many incidents in the immediate zone around schools since that is usually considered the "school zone" where most posted speed limits are much lower than in the surrounding residential and commercial areas. Conversely, this study also assumes that most of the child pedestrian-vehicle incidents involving school children on their commute to-and-from school will occur outside of the school zone, but within a half-of-a-mile from schools, where speed limits may be much higher because they are farther away from school zones. Although this study focuses on the area within .5 miles from school locations along the street network, it is possible that incidents outside of this focus area can also be attributed to the school commute.

Although there have been previous studies which examined pedestrian-vehicle incidents, and child pedestrian-vehicle incidents in particular, little has been done regarding child pedestrian-vehicle incidents in Atlanta, Georgia. The significance of this study is to add to the current literature on pedestrian-vehicle incidents and child safety by providing a case study that examines the causes of child pedestrian-vehicle incidents from 2000 to 2007 with regards to the location of schools, time of day, and walkability of neighborhoods. This study may contribute to the literature by providing information for future research on preventing incidents and improving safety, especially throughout the built environment.

4 Data and Methods

For this study, ArcGIS was used along with data consisting of 1,870 child-pedestrian vehicle incidents occurring between 2000 and 2007 in the five core Metro Atlanta counties, all major roads and highways in Metro Atlanta, and 647 public schools in Metro Atlanta. These files were obtained from the Georgia Department of Transportation, the US Census, Environmental Systems Research Institute (ESRI), and the Atlanta Regional Commission.

The county data was narrowed down to the five “core” counties. These counties include: Fulton, Dekalb, Cobb, Clayton and Gwinnett. The focus of this study is on the immediate area surrounding Atlanta’s city limits. Many lower income neighborhoods are in this study area. The significance of this is that these areas contain the most pedestrians because of the existence of dense development and access to public transit. This is also significant because, based on previous studies, incidents involving pedestrians frequently occur in low-income areas lacking features of the built environment that promote safety and walkability (Zhu et al, 2008). This area within Metro Atlanta was also focused on because, based on previous research, child pedestrian-vehicle incidents related to the location of schools is less likely to occur in suburban areas due to the location of schools being located farther away from residential areas (Watson et al, 2008).

The data was narrowed down to incidents occurring during “school-commuting” hours which includes incidents occurring during weekdays, (Monday through Friday), only occurring between the hours of 6 am and 9 am, and 2 pm and 5 pm. The Atlanta Public Schools’ Website was used to determine when most children would be out of school for holidays and breaks, and that data was narrowed down accordingly. The aforementioned “school-commuting” times were selected because these times included commuting hours for elementary, middle and high school students, and according to the Atlanta Public Schools handbook, school starts at 8 am for elementary, 8:15 am for high school and 8:45 for middle schools (APS Handbook, 2010).

However, it is assumed that children arrive earlier to take part in the school breakfast program, which starts about a half an hour before school starts or to participate in club meetings or even to sit in on detention. The assumption for this study was that many children would begin their journey well before the school day begins, especially if their parents leave for work early. It is assumed that when these children arrive at school, they remain in the school’s cafeteria or common's area until breakfast or until the school day begins. As for the afternoon times, 2 pm to 5 pm were chosen because they allowed enough time to include elementary, middle and high school students, including those that may leave early or leave later in the afternoon because of band practice, tutoring, or other after-school activities.

The incident data was divided up according to the year, month, weekday and time-of-day in which the incidents occurred in order to find trends in the dataset. The incident data was divided according to age cohorts: ages one to four (pre-school), five to 11 (elementary), 12 to 14 (middle school) and 15 to 18 (high school). Information regarding incident severity was extracted from the dataset and divided accordingly based on overall frequencies from 2000 to 2007 and year-by-year in order to find trends. The surrounding speed limits of the incidents were examined in order to judge if a reduction to speed limits should be made, especially with regards to school zones. The condition of roads around resulting incidents were examined, although there proved to be few involved. Other characteristics about the child pedestrians involved in the incidents, other than age, were considered, such as whether or not the child was crossing at a crosswalk.

A network dataset was created in ArcCatalog using the street network file that ESRI provided for the study. The buffers were generated in ArcToolbox and were created to run along the street network in order to judge the path and distance in which school children would travel to-and-from the school locations. The street network was chosen for the buffers to follow rather than Euclidean distance, which may include children who walk through yards, avoiding streets. However, it is assumed that more children walk along the street network where incidents have occurred. The buffers encompassed the street network up to a half-of-a-mile away from each of the 647 school locations, creating five buffers, each representing one-tenth-of-a-mile, up to 0.5

miles. These buffers were created to represent the areas around the schools in which children would travel. The buffers were intended to reach a half-of-a-mile, due to previous studies in which it was stated that children, and pedestrians in general, are more likely to walk to school and other public places if these places are located within a half-of-a-mile. A half-of-a-mile was also chosen because the study area is predominantly urban and densely-developed, thus homes and schools are located within closer proximity than homes and schools in suburban or rural areas, and this is apparent in the outlying areas within the study area (Watson et. al, 2008).

The statistics for the buffers were found in the attribute table in ArcGIS and were examined to judge the frequency of incidents within each buffer area. ArcGIS software was used to generate kernel density analyses, which were used to determine where the five areas with the highest frequencies of incidents occurred during the eight-year time period, as well as, to find if clustering occurred based on age cohort and incident severity. Microsoft Excel was then used to create charts and diagrams to better display the numerical data regarding the incidents.

After finding the areas with the highest frequencies of incidents using the GIS, a walkability assessment was performed in an area around Stone Mountain, which is located in Dekalb County. The Walkability Audit Tool (Saint Louis University School of Public Health, 2003) was used to judge the walkability of this area and to determine the appropriate score for this area, relative to the audit tool. An overall score was given to the area, as well as, individual scores for each street within the area. US Census data (2000) was used to determine income and poverty levels for this area in order to better judge the walkability of Stone Mountain based on a method by Zhu et. al (2008). Stone Mountain was chosen for the walkability assessment because clustering of incidents occurred in Stone Mountain four out of the eight years in the study period.

5 Results

Incidents by Buffers

Results show that, 488 out of the 1,871 child pedestrian-vehicle incidents from 2000 to 2007 occurred during school-commuting hours. 238 out of the 488 (approximately 49%) occurred within the five buffers around each school location. It is noteworthy that there is a decrease in the fourth buffer. Possible reasons for this decrease in the fourth buffer could be due to construction projects and placement of schools within certain distances from large residential areas.

Refer to Appendix A

Incidents by Year

According to the results, it was found that the highest frequency of incidents occurred in 2004, with 71 incidents involving school children during school-commuting hours, followed by 2001 and 2003, in which 69 incidents occurred. A decline in the number of incidents occurred in 2005 and 2006. 2007 had the lowest frequency of incidents, in which 34 incidents involving school children during school-commuting hours occurred.

Refer to Appendices B.

Incidents by Month

This study found that from 2000 to 2007, the month of October had the highest frequency of incidents, with a rate of 87 incidents total. This total is much higher than March and September, which had the second and third highest frequencies at 63 and 61, respectively. It is possible that during these months, children are more likely to walk to school due to pleasant weather conditions that are conducive to walking outside. Also, it is assumed that the lower incident frequencies for the months of June and December are due to school children being out of school for the majority of these months for summer break and winter holidays. **Refer to Appendix C.**

Incidents by Weekday

This study found that approximately 28% of the total incidents during school-commuting hours occurred on Wednesdays. In 2001 and 2004, two spikes in the frequency of incidents occurred on Wednesdays, which resulted in Wednesdays having a higher frequency of incidents.

It is significant that only 0.6% of all incidents during school-commuting hours occurred on Fridays. Due to the typical traffic that ensues, even in the early afternoon hours on Fridays in Metropolitan Atlanta, this study expected that Fridays would have the highest frequency of incidents out of all weekdays. However, it is possible that due to extracurricular activities, sporting events and parents leaving work early on Fridays to pick up their children from school could all be considered as contributory factors for this extreme reduction in the frequency of incidents on this particular day of the week. **Refer to Appendix D.**

Incidents by Time of Day

With regards to the time of day in which most of the incidents occurred, this study found that the least amount of incidents occurred at 6:00 am and 9:00 am. The majority of incidents occurred at 5:00 pm, although this time is not necessarily associated with the school-commute and is rather associated with the work-commute and heavy traffic. 7:00 am and 4:00 pm had similar incident frequencies. This study expected that these times are associated with high volumes of traffic from individuals commuting to work and these times are also associated with the school-commute. 8:00 am and 3:00 pm also have higher frequencies of incidents, similar to those at 7:00 am and 4:00 pm. The frequency of incidents for 2:00 pm is low compared to the other times and this study supposed that this is due to lower volumes of traffic and few school children being out of school at this time.

The incident frequencies for 6:00, 7:00 and 9:00 am and 2:00 pm remain consistent during the 2000 to 2007 time period. However, 8:00 am incident frequencies very more than any other time during the school-commuting hours. This study attributes this to the lower incident frequencies in 2000 and 2007 during this time, with 2007 having incident frequencies that are significantly lower than the other seven years in the study.

Refer to Appendices E through M for additional charts.

Incidents by Age Cohorts

This study found that the two age cohorts of child pedestrians ages five to 11 and 15 to 18, constituting what is considered in this study to be elementary-aged and high school-aged children to make up approximately two-thirds of the total incidents in the study, with each age cohort representing approximately one-third of the total. While children ages 12 to 14 made up approximately 27% of total incidents and children ages one to four making up approximately 6%.

The results from a kernel density analysis of incidents involving elementary school children shows that significant clustering occurred around the Grove Park area in west Atlanta. In this particular area, F.L. Stanton, White, Grove Park, Woodson, Herndon and M.A. Jones Elementary schools are all within close proximity to the cluster of incidents. However, many of these incidents are not included in the buffers for these school locations. This study considered the location of Washington Park and Ashby Circle Playlot are also located in the area, but none of the incidents in the cluster occur around the locations of the parks.

The kernel density analysis for incidents involving highschool-aged children, ages 15 to 18 shows that clustering occurred Downtown around the Georgia State University Campus, Maynard H. Jackson High School and Tech High School, although the incidents did not fall within the buffers for the schools.

Clustering also occurred in Stone Mountain and Redan, in east Atlanta, outside of I-285. The clustering around Stone Mountain occurred around Stone Moutain High School, Clarkston High School and the Gateway to College Academy. The clustering in Redan occurred around Redan High School, although many incidents occurred outside of the buffer for the school.

The results from the kernel density analysis of incidents involving middle school-aged children shows that significant clustering occurred in east Atlanta, south of Zoo Atlanta in the Chosewood Park neighborhood. Daniel Stanton Park is located nearby, as well as, Price Middle School, although the incidents are not within the buffers for the school.

The kernel density analysis for incidents involving children ages one to four shows that slight clustering occurred in Scottdale area, south of Clarkston. Two incidents occurred on North Decatur Road inbetween the locations of Tobie Grant Park and a shopping plaze at the intersection of North Decatur and Memorial Drive, which is also located near Dekalb Technical College and Georgia Perimeter College.

Refer to Appendices N through U.

Incident Severity

This study found that the majority of child pedestrian-vehicle incidents from 2000 to 2007 occuring during school-commuting hours caused visible injuries to the child involved in the incident. Visible injuries can involve injuries to any body part. The severity type with the second highest incident rating was incidents considered complaints, or where a child was possibly struck but had no life-threatening wounds or injuries, but the incident was nevertheless reported. Incidents with victims considered to be uninjured was considered to have the third highest ranking. Serious injuries and fatalities had the lowest incident frequencies out of the five different severity types.

It was found that the majority of incidents in the study area are not life-threatening. It is significant to note that serious injuries (life-threatening) and fatalities had the lowest frequencies of incidence in the study area. However, it is more significant to note the locations of these different types of incidents in terms of severity. Visible injuries, complaints and serious injuries are dispersed across the study area, except for what appears to be slight clustering around a particular area of interest around West End in southwest, Atlanta. While fatalities and incidents, where the victims were considered uninjured do not appear to have any clustering. Although there appears to be clustering in the area around West End for three of the injury classifications, no fatalities have occurred in this area. There are also large areas on the outskirts of the study area in south and north Fulton County and a large portion of Gwinnett County did not have any incidents from 2000 to 2007 during school-commuting hours. This study supposes that this is attributed to these areas being suburban and that many schools are located farther away from neighborhoods, so that school children are less likely to walk to school.

This study found that 40% of serious incidents occurred in areas with a posted speed limit of 25 mph and 33% occurred in areas with a posted speed limit of 35 mph. This is significant because these speed limits are relatively low compared to typical speed limits along major roads and highways (i.e. 45 or 55 mph). This study also found that 31 out of the 55 incidents (56%) with reported serious injuries did not occur within buffers around school locations. This is significant because, typically, the posted speed limits around schools are 25 mph. These findings suggest that 40% of these incidents with reported serious injuries occur in areas outside of the school with a posted speed limit of 25 mph and it is assumed that these could be residential or commercial areas. After running a kernel density analysis in ArcMap, the study found that a clustering of incidents occurred around the West Lake area in west Atlanta.

With regards to incidents with victims reporting that they were uninjured, 33% occurred in areas with a posted speed limit of 25 mph, 38% with a posted speed limit of 35 mph. Approximately 48% of the incidents with victims reporting that they were uninjured occurred outside of the buffers around school locations. A kernel density analysis shows slight clustering again around the West Lake area and Downtown.

This study found that approximately 70% of incidents with reported visible injuries occurred in areas with a speed limit of 25 and 35 mph. Approximately 61% of incidents with reported visible injuries occurred outside of the buffers around school locations. According to the results from the kernel density analysis, clustering occurred in the area around Grady Hospital Downtown, West Lake and West End.

This study found that 67% of incidents reported as complaints occurred in areas with a posted speed limit of 25 to 35 mph. Approximately 56% of incidents reported as complaints occurred outside of buffers around school locations. The results from the kernel density analysis displayed clustering in the West Lake area, the Candler-McAfee area near Decatur, and near Stone Mountain.

All of the nine fatalities occurred outside of the buffers around school locations. However, approximately 56% of fatalities occurred in areas with a posted speed limit of 25 and 35 mph. This study assumes that other features of the built environment should be considered other than speed limit. Furthermore, it should be noted that the posted speed limit was reported and not necessarily the speed of the driver. Furthermore, this study found that incidents with reported fatalities are not clustered, but instead are randomly spread across the study area. However, six out of the nine (approximately 67%) of incidents with reported fatalities occurred outside of I-285.

Refer to Appendices W through AG.

Incident Severity by Year

In 2000 there were no reported fatalalities. Approximately 49% of the incidents reported visible injuries. 30% of the incidents during 2000 involved victims with reported complaints. A kernel density analysis shows that there is clustering around the West Lake area and Vine City area.

In 2001, four fatalities occurred. Nearly half of the total number of fatalities during the study period occurred in 2001. One of these fatalaties occurred in a location where another reported incident, one with visible injuries, also occurred. However, this location is within close proximity to, but not within the buffer of, an elementary school, although these incidents involved high school-aged children. 69 incidents total occurred during 2001. Visible injuries and complaints account for 71% of the total number of reported incidents. According to the results from the kernel density analysis, there is clustering around the Oakland City area, Downtown and Vine City and Stone Mountain.

In 2002, there were no reported fatalities. 64 total incidents occurred during that year. 71% were reported visible injuries and complaints. The incidents appear to be rather dispersed. However, a kernel density analysis shows that there is slight clustering around the Peoplestown neighborhood in southeast Atlanta and around the Stone Mountain area.

In 2003 there were two reported fatalities, both occurring in Cobb County and in areas without overlap with other incidents. 69 total incidents occurred this year. 65% of these incidents reported visible injuries and complaints. The kernel density analysis shows that there is clustering around the Stone Mountain area.

In 2004 there were 71 total incidents and two reported fatalities, one in Cobb County and one near Decatur in Dekalb County. Incidents with reported visible injuries and complaints make up the majority of incidents reported. Reported visible injuries and complaints account for 75% of the total incidents reported that year.The incidents appear to be dispersed across the study area. However, there is clustering in the Morrow area of Clayton County, according to the kernel density analysis.

In 2005, there was one reported fatality, which occurred in Gwinnett County. 59 total incidents occurred in 2005. According to the kernel density analysis there appears to be slight clusering around I-20 in the Panthersville and Candler-McAfee area near Decatur in Dekalb County, in Jonesboro in Clayton County and in the Smyrna area in Cobb County. Again 75% of the total incidents were reported visible injuries and complaints. The fatality involved a high school-aged child, and although the incident did not occur within any buffers, the incident occurred in an area within close proximity to a combined middle and high school.

In 2006 there were 55 reported incidents and no fatalities. 73% of the incidents reported visible injuries or complaints. The results from the kernel density analysis show slight clustering around the Clarkston area in Dekalb County. Only one incident occurred in Clayton County that year.

Lastly, in 2007, the lowest rate of incidents occurred with a reported 34 incidents that year. There were no reported fatalities. Similar to the previous years in the study, 74% of incidents reported visible injuries and complaints. The incidents appear to be dispersed in most of the study area. However, according to the kernel density analysis, the results show that there is clustering around the Whittier Mill area in northwest Atlanta.

Refer to Appendices AH through AO.

Incidents by Speed Limit

The majority of incidents occurred in areas where the posted speed limit was 25 and 35 mph (33 and 35%, respectively). Approximately 15% of total incidents occurred in areas with a posted speed limit of 45 mph. Surprisingly, areas with a higher posted speed limits were not associated with higher incident frequencies. In fact, approximately 1% of incidents occurred in areas with a posted speed limit of 55 mph. This is likely due to fewer people walking in these areas with higher posted speed limits, such as areas near interstate highways and major thoroughfares. The higher incident frequencies for areas with lower posted speed limits can be attributed to a false sense of security felt by pedestrians who are expecting drivers to drive at a slower speed. Also, it is likely that these areas have greater number of pedestrians in general because of this false sense of security.

Refer to Appendices AP.

Incidents by Road Condition Defects

Out of the 488 total incidents in the study area, only 11 of these incidents had reported road condition defects that were attributed to the incident. The surrounding area in the remaining 477 incidents were reported as having no defects. 36% of the incidents with road condition defects reported were considered roads with running water. It was found that none of the incidents with road condition defects reported occurred North of I-20, within I-285. It also appears that the majority of these reported incidents with road condition defects occurred along the I-20 corridor. Lastly, it was found that two incidents occurring in the same location near Perkerson Park in southcentral Atlanta involving two high school-aged children, reported the road condition defects as running water in the road.

Refer to Appendix AQ.

Incidents Involving Pedestrians Crossing at Crosswalks

Approximately 16% of the total number of incidents in the study period occurred while child pedestrians were crossing the street at an assigned crosswalk. A kernel density analysis shows that slight clustering of these incidents occurred in the Downtown area, the Lakewood Heights area in Southeast Atlanta, and in the Perkerson and Avery Park areas southwest of Downtown. This study assumes that this is likely due to high volumes of traffic, speeding and large volumes of pedestrians in these areas possibly crossing at a crosswalk, but not obeying the signal.

Refer to Appendices AR through AS.

Incidents Involving Pedestrians Crossing Without a Crosswalk

46% of the total 488 incidents in the study involved child pedestrians crossing the street without a crosswalk. The reports do not specify as to whether the child was crossing at a marked intersection, but it is assumed that this implies that the child was crossing at a marked intersection that was lacking a marked crosswalk. The results from the kernel density analysis suggest that there is clustering around the Ashview Heights and Hunter Hills area in West Atlanta, just west of Downtown. This is significant because these areas may be lacking marked crosswalks where child pedestrians frequent the area.

Refer to Appendices AT through AU.

Five Areas in Metropolitan Atlanta with Highest Incident Frequencies

2000

In 2000, according to the kernel density analysis the densest area of clustering occurred around the Simpon Road and Joseph E. Lowry Boulevard intersection, near Maddox Park, Herndon Elementary School and the Bankhead MARTA station in West Atlanta, near West Lake and West End. The area with the second densest clustering occurred in Decatur, near Low Walker Park, Towers High School and Glen Haven Elementary School, in the area south of Covington Highway (US 278) and Glenwood Road (SR 260). The area with the third densest clustering occurred in the Redan area, West of the Redan Road and Hairston Road intersection, near Redan High School. The fourth densest area of clustering occurred in the Westview area in Southwest Atlanta, near Gorden White Park. Lastly, the fifth densest area of clustering occurred near the Bolton area in Northwest Atlanta, near Chattahoochee Trail Park, Riverside Park and Williams Elementary School, North of Bolton Road and East of James Jackson Parkway (SR 280).

2001

In 2001, according to the kernel density analysis, the area with the densest amount of clustering of incidents occurred in Stone Mountain, South of Ponce de Leon Avenue, West of North Hairston Road, around the location of Stone Mountain High School. The area with the second densest clustering of incidents occurred in the Ashview Heights area in West Atlanta, West of Joseph E. Lowry Boulevard and South of Martin Luther King Junior Drive and North of Westview Drive, near Strafford Street Park and M.A. Jones Elementary School. The third densest area of clustering occurred West of Downtown, North of Martin Luther King Junior Drive, South of Andrew Young Boulevard and East of Bethune Elementary School, near Centennial Olympic Park. The fourth densest area of clustering occurred near the Campbellton

Road and Stanton Road intersection in southwest Atlanta, near Venetian Hills Elementary School. Lastly, the fifth densest area of clustering occurred in South Atlanta near Capital View Elementary School and Emma Millican Park, North of Atlanta Metropolitan College and Atlanta Junior College.

2002

The kernel density analysis for 2002 shows that the densest area of clustering of incidents occurred in Stone Mountain, North of Memorial Drive (SR 10), North of Central Drive and East of Hairston Road, near Stone Mill Elementary School. The area with the second densest clustering occurred in Southeast Atlanta, West of Boulevard and North of McDonough Boulevard (SR 42) near Benteen Elementary School. The third densest area occurred in West Atlanta, West of Joseph E. Lowry Boulevard and North of Simpson Road, near Maddox Park and Herndon Elementary School. The fourth densest area of clustering occurred in Decatur and Belvedere Park, near the Colombia Drive and Memorial Drive intersection, near Hooper Alexander Elementary School and Dekalb Early College Academy and a Kroger shopping plaza. Lastly, the fifth densest area of clustering occurred East of Downtown, near the Ralph McGill Boulevard and Boulevard intersection, around Freedom Parkway, near Hope Elementary School.

2003

In 2003, according to the results from the kernel density analysis, the large area with the densest clustering of incidents occurred in Stone Mountain, near the Stone Mountain Lithonia Road and Rockbridge Road intersection, near Wade Walker County Park, Randolph Medlock Park and Eldridge L. Miller Elementary School. The second densest area occurred near Maddox Park and Herndon Elementary in West Atlanta. The third densest clustering occurred in East Atlanta, near Hosea L. Williams Drive, near Crim High School, Coan Middle School, Toomer

Elementary School, Whitefoord Elementary School, the Edgewood-Candler MARTA station and Coan and Gilliam parks. The fourth densest area of clustering occurred in Conley, in Southeast Atlanta, near Anderson Elementary and Conley Park. Lastly, the fifth densest area of clustering occurred in a large area in College Park in Clayton County, near Northcutt Elementary School and North Clayton High School and the North Clayton Village Shopping Center.

2004

In 2004, the area with the densest clustering of incidents occurred near West End in West Atlanta, near Brown Middle School, Howell Park and the West End Shopping Center. The area with the second densest clustering occurred in Morrow in Clayton County at the location of Morrow Middle School and near Morrow High School and Thurgood Marshall Elementary School and the Tar Creek Mini Park. The third densest area occurred near the I-20 and I-285 interchange in West Atlanta, near Fain Elementary School, Harper-Archer Middle School, Adamsville Gym Park, Adamsville-Collier Heights Library and the Adamsville Recreation Center. The fourth densest area occurred in Southwest Atlanta, near, but not within the buffer zones of Cascade Elementary and Venetian Hills Elementary schools and very close to Pomona Park. The fifth densest area of clustering occurred in the Candler-McAfee area near Decatur, near Snapfinger and Knollwood Elementary schools.

2005

The results from the kernel density analysis show that the area with the densest clustering of incidents occurred in Marietta, East of Austell Road (SR 5), near the Olive Springs Road and Windy Hill Road intersection, near LaBelle Elementary School. The second densest area of incidents occurred in the Candler-McAfee area in Decatur, near McNair Middle School. The third densest area occurred in Jonesboro in Clayton County, West of Pointe South Elementary

School and South of Kendrick Middle School, but not within the buffer zones of the schools. The fourth densest area occurred near the Atlanta Silverbacks soccer park, near the intersection of I-85 and I-285, near Doraville. The fifth densest area occurred in Mableton in Cobb County, West of Harmony-Leland Elementary School, near Lions Park.

2006

According to the kernel density analysis, the densest clustering occurred in North Decatur, East of Shamrock Middle School, North of Lawrenceville Highway. These incidents occurred within the buffers for Shamrock Middle School and involved late elementary-aged and middle school-aged children. The second densest area occurred East of Downtown, near Hope Elementary School, Freedom Park and Boulevard-Angier Park, East of Atlanta Medical Center. The third densest area occurred in West Atlanta, near Woodson, Grove Park and White elementary schools and near Grove Park, Gertrude Place and Elinor Place parks. The fourth densest area occurred in Southeast Atlanta, near Thomasville Heights Elementary School and Thomasville Park. The incidents involved elementary-aged children and the incident locations fell within the buffers of Thomasville Heights Elementary School. The fifth densest area occurred in Stone Mountain, near the East Dekalb Special Education Center.

2007

According to the results from the kernel density analysis, the area with the densest clustering of incidents occurred in northwest Atlanta, near Scott Elementary School and Washington High School, near Spink-Collins Park. The second densest area occurred in Lawrenceville in Gwinnett County, West of Kanoheda Elementary School. The third densest area occurred Downtown near Centennial Place Elementary School. The fourth densest clustering occurred near the Decatur and Stone Mountain line in Dekalb County, near Belvedere

Park, near Hooper Alexander Elementary School and Dekalb Early College Academy. Lastly, the fifth densest area occurred near Mary M. Bethune Elementary and McNair Middle schools and Burdett Park in College Park in South Fulton County.

Refer to Appendices AV through BC.

Walkability Assessment of Stone Mountain in Dekalb County

A walkability assessment was conducted for the area around Stone Mountain High School and Hambrick Elementary School in Stone Mountain in Dekalb County. The assessment was conducted after examining the kernel density analyses for the eight-year study period. It was found that out of the 40 areas, clustering of incidents in Stone Mountain appeared four times in the kernel density analyses.

The area in which the assessment was conducted was to the south of Central Drive, north of Memorial Drive and in-between Hambrick Road and North Hairstron Road. This study found that sidewalks lined all of the streets in the study area, and it was found that all of the sidewalks were in good condition, without broken or missing sections. Although there were sidewalks in-use on all streets in the study area, there were not any bike lanes. During the assessment, numerous pedestrians were using the sidewalks. Some middle school aged children were present, using bikes, and were forced to ride in the street, in dangerous areas where the road followed a hill and presented a view obstruction for drivers.

North Hairstron Road contained adequate crosswalks in each intersection. However, it was noted that there were long stretches of the four-lane road in which there were no intersections present, thus presenting a risk for pedestrians unwilling to walk to the next upcoming intersection to cross. Crosswalks were present in front of the schools. However, they were not raised, there was no signal; only signage at the crosswalk signaling school children crossing at the location. It was also noted that the crosswalk in front of the high school was at a midpoint on a hill, thus presenting a dangerous area for children to cross.

The area surrounding the schools was predominantly residential, although there were industrial businesses and shopping located nearby on Memorial Drive and farther south on North Hairstron Road. There were many single-family homes and neighborhoods along Hambrick Road and Central Drive. However, there were also numerous apartment complexes located along Central Drive and North Hairstron, including a large complex along the stretch of the four-lane road lacking intersections with crosswalks.

The posted speed limit for the area was 35 mph, even in front of the high school. However, in front of the elementary school on Hambrick Road there was a 25 mph “when flashing” signal. It was noted that a small, connecting street, in-between the two schools, which contained several single-family homes was also marked 25 mph.

During the assessment, it was noted that numerous pedestrians were present. The majority of these pedestrians appeared to be middle school and high school aged children. It was also noted that during the assessment, two young men with a toddler crossed the street in front of a convenience store, not at an intersection, thus presenting the need for the installation of crosswalks at convenient locations may be necessary.

Using the walkability assessement audit tool checklist (Saint Louis University School of Public Health, 2003), the area around Stone Mountain High School received a score of 58.3. The average score for Atlanta neighborhoods is around 50. The audit tool considered various aspects of the built and natural environment including: building types, commercial properties, public services, recreational facilities, land use classes, natural features, street characteristics, aesthetic features, pollution and disorder, signage and people. The audit tool required a response to whether or not each specific feature was visble or not visible upon initial examination of the area.

Refer to Appendices BD through BO.

6 Discussion

Regarding Frequencies of Incidents Within Buffers

The frequency of incidents occurring in the buffer areas supported the first hypothesis in the study, in that the least amount of incidents, relative to the buffers, occurred in the buffers closest to the school zone. The results are also in-line with the third hypothesis, in that, out of the buffer zones, the highest frequency of incidents occurs in the farthest outlying buffer zone (.5 miles). However, the frequency of incidents does not follow the assumed trend of the study, in that there would be a steady increase in the frequency of incidents from the first buffer to the fifth. It is significant that the second and fourth buffers are similar in frequencies, while the third and fifth buffers are similar in frequencies. The decrease in the fourth buffer, in which the frequency is lower than that of the second buffer, is noteworthy. It was found that the fourth buffer has the lowest frequency rate of incidents.

Although the decrease in incidents at the fourth buffer could have occurred by chance, there could be underlying causes for this decrease. Initially, this study supposed that perhaps because of the location of urban schools being located within close proximity to residential areas, this could account for a decrease in the frequency of incidents. However, this does not account for the steady increase in the second and third buffers around schools. This study suggests that there may be a false sense of security experienced by children walking to school outside of the school zone, but within .4 miles of the school location. Perhaps there are more children present in these areas because it is closer to the school zone, and, thus, the children assume that because there are large groups of them and because they are within close proximity to the schools, they must therefore be seen by drivers and are therefore safe from harm. At the .4 miles buffer, this sense of security may not be present, and, thus, children may become more aware of the dangers of vehicle incidents, coupled with the fact that there may be fewer children present at this distance from the school, or they may not travel in groups or meet up with other groups until they are closer to the school. At the .5 miles location, the increase can thus signify, perhaps not the children's lack of awareness, but the existence of higher speeds and fewer signs acknowledging the existence of school children and a nearby school location although there may be fewer child-pedestrians present at this distance from the school.

Regarding Incidents by Year

There appears to be a steady increase in the total number of incidents from 2000 to 2004, with a slight decrease in 2002, and then steadily decreasing in 2005 and 2006, with a much lower frequency of incidents in 2007. This seems hopeful that perhaps changes have been made to safety features, driving laws, or built environment features to somehow cause such a reduction in the total number of child-pedestrian incidents in this short period of time. However, recent data is needed to confirm this.

This study assumes that perhaps the slight decrease in incidents in 2002 may have been due to chance. With the high rate of 71 incidents occurring in 2004, perhaps this signaled the need for changes to be made in Metro Atlanta. A decrease of 37 child pedestrian incidents in three years is certainly significant.

Regarding Incidents by Month

This study found that during the eight-year time period, the majority of incidents occurred during the month of October. This study assumes that this could be attributed to weather conditions in Georgia. The pleasant temperature and weather conditions for this time of year could be inviting for children who may not be willing to walk to school during other months due to extreme heat, cold or various weather conditions.

This study also found that, following October, March and September had higher incident frequencies than other months during the year. This can also be attributed to pleasant weather conditions during these months. An increase in the number of children present walking to-and-from school would thus increase the risk of child pedestrians being involved in incidents.

It was also found that the least number of incidents occurred during the months of June and December. This study assumes that this is due to children being out of school at this time of the year. In December, many children are out of school and in Georgia, typical weather conditions are not conducive to walking. However, this study cannot explain the reduction in the frequency of incidents during the month of June, based on the previous assumption for the month of December. Due to the fact that many school children in Metro Atlanta would be out of school during the month of June, many children may be walking to other destinations, such as parks during this time and there may be an actual increase during this time. However, this study did not consider the month of June for this reason.

Regarding Incidents by Weekday

It is unclear as to what caused these incidents to take place on Wednesdays. Further examination of traffic data needs to be analyze, as well as, information regarding construction project schedules during this time period and special events and other occurrences that would increase traffic, making pedestrians more vulnerable to being struck by vehicles. Due to the frequency of incidents for Wednesday being high because of the higher frequencies in 2001 and 2004, these years need to be considered. Atlanta Public Schools' activity schedule should also be considered to determine if any school or community-wide activities took place on Wednesdays that could have caused this increase.

Regarding Time of Day

The results from the study suggest that, not only does the school-commute play a role in determining how many incidents occur at different times, but also the traffic patterns and the rush-hour commute also play a role. With more vehicles on the road, children will inevitably be at-risk of being injured in a pedestrian-vehicle incident. This study assumes that this can explain why the majority of incidents occurred at 5:00 pm; a time when many vehicles are on the road and the Metro Atlanta rush-hour is underway. Conversely, this can also explain why fewer incidents occurred at 6:00 and 9:00 am; these are times when commuters are not on the road, and, thus, children are not as at-risk. Furthermore, these times are less-associated with the school-commute, and, therefore, fewer children will likely be walking to-and-from school at these times.

Regarding Age Cohorts

With regards to age cohorts, this study found that the majority of incidents during school-commuting hours involved children ages five to 11 and 15 to 18 (elementary and high school). This finding is in-line with findings from previous literature, in that most child pedestrian-vehicle incidents involve children around the age of seven. Young children (babies, toddlers and preschool-aged) were least likely to be involved in incidents. This is likely due to children at this age being under strict adult supervision.

This study assumed that the buffers extending out to half-of-a-mile typically included incidents involving children who would presumably attend the corresponding school in which the buffers encircle. However, numerous incidents involving children that may attend neighboring schools were also included in the buffer counts. This is attributed to the location of multiple schools being located within close proximity (i.e. elementary, middle and high schools on one campus and alternative and night schools also being located within close proximity to other schools). Also, some incidents involving school-aged children who would presumably attend schools nearby the location of the incident were not included in the buffers. This is attributed to the buffers only reaching .5 miles, rather than one mile or greater.

This study assumes that the clustering of incidents involving elementary children is attributed to the neighborhood of Grove Park. Although schools and parks are located nearby, the incidents occurred within residential areas. Perhaps there really aren't enough parks in the area for children to play safely.

The clustering of incidents involving high school-aged children downtown is attributed to the amount of traffic downtown and the availability of numerous shops, restaurants and attractions, including parks, for high schoolers to go after school. This assumption is based off the fact that all of the incidents involving high school children in the Downtown area occurred after school, mostly at 4:00 and 5:00 pm, during rush-hour traffic.

The clustering involving high school children in Stone Mountain and Redan can be attributed to the location of high schools in the area. However, the existence of various shopping plazas in the area can also attribute to the clustering.

As with the clustering of incidents involving elementary school children occurring mainly in residential areas, the same appears to be true for middle school children. Schools, Zoo Atlanta and parks are located nearby, but the incidents mainly occur in residential areas. Perhaps safe parks and playlots and basketball courts should be added to this area as well, to ensure that children have a safe place to play, rather than in the street.

This study assumes that the incidents involving children ages one to four occurring in the area around Scottdale and Decatur involved children who were attended by an adult on their way to-and-from Tobie Grant Park or one of the shopping plazas in the area. This study supposes that these children involved in the incidents may have been walking with their parents to-and-from one of the colleges in the area.

Regarding Incident Severity

Although it is unfortunate that incidents occurred in Metro Atlanta, it is fortunate that incidents with reported serious injuries and fatalities accounted for the least amount of incidents overall. Because visible injuries, complaints and incidents with reported uninjured child pedestrians make up the majority of the total incidents, perhaps the children involved are taking risks, even in areas with lower speed limits such as 25 mph, thus resulting in non-life-threatening incidents.

This study supposes that because these areas are suburban, many children involved in the incidents may not be walking to school. Therefore, this study assumes that these incidents involved children walking to other destinations, and the existence of possible higher speed limits in these suburban areas may have contributed to the incidents due to drivers failing to slow down in certain areas where child pedestrians are present.

Regarding Speed Limit

This study assumes that the existence of lower posted speed limits in the areas where the majority of child pedestrian-vehicle incidents occurred in the study area still suggests that speed limit plays a role in the cause of incidents. It should be noted that although the majority of the posted speed limits in the areas where incidents occurred are 25 and 35 mph, this does not mean that the drivers involved in the incidents were driving the speed limit. It is unclear as whether drivers involved in these incidents were in-compliance with the posted speed limits.

Regarding Road Condition Defects

This study assumes that due to the fact that road condition defects were rarely reported in the incidents in this study, it is assumed that other factors of the built environment were involved. Perhaps road condition defects were not considered at the time of the incident because the speed limit, lack of crosswalks, and other built environment factors were considered instead. Due to the fact that 36% of incidents with reported road condition defects involved running water, this study assumes that due to a break in a water main or a heavy rainstorm, pedestrians may have walked in the street instead of on muddy sidewalks or where gushing water was located, resulting in an incident.

This study suggests that road conditions do not necessarily play a role in incident frequencies. This study found that only 11 out the 488 incidents during school-commuting hours reported road condition defects in the incident report. Although road conditions describe the built environment in an area, this study considers other factors of the built environment to be more influential in increasing or decreasing incident frequencies in the study area.

This study also suggests that weather conditions do not necessarily have an effect on incident frequencies. In previous research, it was found that there are fewer pedestrians on the road during inclement weather, thus, reducing the risk of pedestrian injury from pedestrian-vehicle incidents. The data in this study is in-line with previous research, in that the majority of incidents in the study occurred on days that the weather was not described as inclement.

Regarding Incidents with Pedestrians Crossing at Crosswalks

Although the children involved in incidents in which it was reported that they were crossing at assigned crosswalks, they may not have been using these crosswalks properly. Due to childrens' lack of awareness and participation in risky behavior, children involved in incidents at assigned crosswalks, may have taken the initiative to cross the street, assuming that it was safe simply because it was a crosswalk. This false sense of security may be the leading cause in incidents involving child pedestrians at crosswalks. Therefore, this study suggests that children's impulsive behaviors, childrens' smaller stature and therefore, slower walking pace, may require the need for extending signals to allow children to cross the street safely. The existence of clustering around Downtown and southeast Atlanta is likely due to high volumes of traffic, speeding and large volumes of pedestrians in these areas possibly crossing at a crosswalk, but not obeying the signal. Due to high volumes of traffic and short block distances, drivers may be more likely to run redlights, thus resulting in incidents at crosswalks in these areas in Atlanta.

Regarding Incidents Involving Pedestrians Crossing Without a Crosswalk

The incident reports involving child pedestrians crossing the street, but not at an assigned crosswalk do not specify as to whether the child was crossing at a marked intersection, but this study assumes that this implies that the child was crossing at a marked intersection that was lacking a marked crosswalk or simply darting across the street. It is significant that nearly half of the incidents in the study involved child pedestrians being struck crossing the street where crosswalks were not present. This study assumes that this implies that there is a need for crosswalks in Metro Atlanta. Furthermore, this study assumes that the addition of crosswalks with signals at locations along streets that enable pedestrians to cross safely and cross at locations that are convenient to points of interest and public transit will reduce the number of incidents involving child pedestrians in Metro Atlanta.

Regarding Clustered Areas by Year

The incidents in 2000 mainly occurred near the locations of pocket parks in the study area, with the exception of the incidents occurring in Stone Mountain around Stone Mountain High School. In 2001, again Stone Mountain High School had a clustering of incidents around the location of the school. The remaining incidents in 2001 occurred within close proximity to schools and the high-traffic Downtown area. However, some of these incidents did not occur within school buffers. In 2002, again Stone Mountain contained a clustering of incidents, except that these incidents occurred around a different school in the area. The remaining clusters occurred near schools, a park and shopping plazas.

In 2003, Stone Mountain again, had a large, clustered area, but these incidents occurred around a different school and a couple of parks. The remaining incidents in 2003 occurred within close proximity to schools, but not necessarily within buffers of these schools and near parks, a MARTA station and shopping plazas.

In 2004, two of the five clustered areas involved incidents within close proximity to neighborhood recreation centers. Some incidents occurred near school locations, but were also within close proximity to parks, a library and shopping plazas.

In 2005, two out of the five clustered areas occurred in Marietta, and one cluster occurred in Mabelton. Only one clustered area occurred within I-285 during 2005, and the remaining clusters occurred in the suburbs. These incidents occurred near schools, but few occurred within buffers, likely due to the fact schools in suburban areas are located farther away from residential areas. In 2006, many of the incidents occurred near schools and occurred within buffers of these schools.

Incidents during 2006 also occurred near parks and some high-traffic areas, such as the Downtown area. Lastly, in 2007, again Stone Mountain contained a clustering of incidents, near a school, but not within its buffer. This study finds it interesting that a cluster of incidents occurred in Lawrenceville in Gwinnett County. This was the only occurrence where a cluster of incidents in Gwinnett was noted.

After examining the five, most densely-clustered areas for each year of the study, it appears that Stone Mountain in Dekalb County contains the most clustering of incidents. This study finds this to be significant because the original belief was that the area with the highest rate of clustering would be within I-285 in a densely-developed area that is low-income and therefore reliant on public transit. It is significant that a smaller geographic area would contain clustering. This study assumes that this implies that there is a need for improvements in the built environment in the area around Stone Mountain, mainly Stone Mountain High School.

However, although Stone Mountain has the densest clustering of incidents, west Atlanta, north of I-20 has the highest number of incidents overall. This study also finds this to be significant, in that there is also a need for improvements in this large geographic area.

An altertnative to simply finding clusters of incidents based on the overall number of incidents in a an area, school districts could have been examined, with regards to how many children attend each school. Accessing school district information would allow for a reasonable walking distance to be assigned to each district. In such cases, the use of .5 mile and one mile buffers could be determined based on the predetermined walking distance for each district. The total enrollment for each school district could then be divided by the total number of incidents during the study period for that area. A percentage could then be provided for each district and the clusters could then be determined from these findings.

Regarding the Walkability Assessment of Stone Mountain

Using the walkability audit tool, scores were assigned to the overall area and each individual street within the area, with higher scores indicating a more "walkable" area. According to the walkability assessment of the study area in Stone Mountain, in which Stone Mountain High School and Hambrick Elementary are located, the overall score for the area was a 58.3. This score is slightly above average for most Atlanta neighborhoods (50) (walk score, 2011), however, it is much lower than the average score given to walkable neighborhoods (70). This study attributes this score to the existence of mixed development, sidewalks on all major streets and roads, standard crosswalks at most intersections, and heavy usage of sidewalks and public transit by residents of the area.

The individual scores for the study area ranged from 36.1 for the segment of Memorial Drive in the study area, to 50.8 for Hambrick Road. North Hairstron road received a score of 44.4 and Central Drive received a score of 49.7. Although the scores are appropriate, relative to the study area, this study finds these scores to be slightly inflated. This inflation is due to the existence of sidewalks, crosswalks and low speeds, as well as, mixed development in the area. Although all of these characteristics make the area "walkable" in terms of having multiple destinations located in the area and having the means to reach these destinations via sidewalks or public transit, the walkability of these streets should not be equated with safety of pedestrians.

This study also found that, according to the US Census data for 2005 through 2009, the area of Stone Mountain is above the national levels for poverty for families and individuals. According to the US Census, 22.9 percent of families are below the poverty line, while the national level is 9.9 percent. In Stone Mountain, 22.8 percent of individuals are below the poverty line, while the national level is at 13.5 percent. This study also found that, out of individuals 16 and older who work, 10 percent do not drive, and therefore, rely on walking or public transit. However, this information does not necessarily support the findings in this study regarding the area of Stone Mountain, due to the fact that only 17 percent of the incidents involved high school aged children 16 to 18 years of age.

An alternative to the method used in this study would include the use of community members and residents. Comparative walkability assessments could be performed by increasing the sample size with the assistance of groups of residents. Each resident would be assigned a copy of the walkability audit tool, in which they could include their own scoring of the area. In the case that an area lacks adequate built environment features that are conducive to safe walking, it may be an issue of environmental justice, in which case, the assistance of residents would help immensely in better understanding what resources are needed in a particular area.

7 Limitations

This study is limited by a number of different factors, mainly that the subject of child pedestrian-vehicle incidents encompasses an infinite number of aspects and this study was unable to cover the expansive list of possible factors involved in child pedestrian-vehicle incidents in Metro Atlanta. However, this study's aim was in analyzing child pedestrian-vehicle incidents as they relate to the location of schools and the time of day related to the school commute. Narrowing down the data to Metro Atlanta's five core county area helped in providing a case study example, but not necessarily one that is applicable in all settings.

A limitation of this study that is in need of being researched in order for the results from this study to reach their potential in improving the safety and walkability of Metro Atlanta is the need for child pedestrian-vehicle incident data to be obtained for the years 2008 to the present. This study is limited by the fact that the information provided in the study is dated. The data is from 2000 to 2007, although the study was conducted from 2010 to 2011. Due to the fact that the incident data is not recent, conclusions cannot be made regarding changes to the built environment and improvements to safety in all areas of the study, only the area examined in the walkability assessment. Following the walkability assessment, project reports and evaluations from the GDOT and Dekalb County Board of Education still need to be examined. Incident data from 2008 to the present needs to be obtained from the GDOT to find whether child pedestrian-vehicle incident frequencies have decreased and which areas have had the most significant reduction in the number of incidents. Furthermore, examination needs to be conducted on an individual scale in order to judge whether changes have been made across the study area.

This study is also limited by the fact that the study only examined the area that is .5 miles outside of each school location in the study area. Although the decision to do this was based on previous studies, expanding the buffers to encompass up to one mile outside of each school location may have resulted in significant findings regarding the incident data. Although the majority of the information obtained from this study is regarding the trends found in the dataset, additional information regarding school locations and the influence that school locations have on incident frequencies may have been obtained from expanding the buffers around the schools.

The results from examining the buffers up to .5 miles away from each school location suggested that incidents typically happen farther away from school locations, with the exception that there is a reduction in incident frequencies at .4 miles away from schools. This finding cannot be explained by this study. Further research needs to be conducted to better understand these findings.

8 Conclusion

The findings from this study suggest that the location of schools and the school-commute can be attributed to the frequency of incidents involving child pedestrians in Metro Atlanta. However, many other aspects are involved other than schools and the school commute. This study found that incident frequencies appear to be lowest around school zones, or the immediate areas around school locations.

This study found that, as school children leave the school zone, their risk of being involved in pedestrian-vehicle incidents increases slightly. The farther the child travels outside of the school zone, their risk increases due to the fact that large groups of child pedestrians are typically found closer to schools, thus, making it easier for drivers to see these groups of children. Farther away from the school, children may walk alone, making them vulnerable to being involved in incidents. Also, as the child travels even farther away from the school, speed limits typically increase and there is typically mixed-use development where drivers may not be aware of child pedestrians, thus, placing them at an even greater risk of being struck by a vehicle.

This study found that the methods used in this study cannot necessarily be used in the context of the suburban environment. As previous research has found, in suburbs, schools are typically located farther away from residential areas, thus, school children are less likely to walk to school. Conversely, this study suggests that child pedestrians are at-risk of being involved in pedestrian-vehicle incidents in the Downtown area due to higher volumes of traffic.

This study suggests that traffic patterns and the rush-hour commute associated with urban and suburban areas plays a major role in incident frequencies in this study. This study found that higher incident frequencies were associated with high traffic volume times: 7:00 am, 3:00, 4:00 and 5:00 pm. While lower incident frequencies were associated with times in which commuters were less likely to be on the roads: 6:00 am and 9:00 am. However, these times are also associated with school times, in that these times associated with lower incident frequencies are also associated with times in which school children would have either not left for school yet or have already arrived at school.

This study found that non-lifethreatening injuries were associated with incidents in the study area. Although incidents with reported visible injuries accounted for the majority of reported incident injuries, serious injuries and fatalities accounted for a small percentage of total incidents during the study period. These findings suggest that, due to the existence of non-lifethreatening injuries or no injuries being reported, perhaps children are making sudden decisions, such as darting out in-front of a moving vehicle. In this case, a driver would see the child dart out and would be able to slow down, so as to not cause serious injury upon collision.

This study found that the majority of incidents in the study period, regardless of incident severity type, occurred in areas with posted speed limits of 25 and 35 mph. This was contrary to what was expected: that the majority of injuries would occur in areas with higher posted speed limits, when in fact, only 1% of injuries occurrd in areas with a posted speed limit of 55 mph. These findings suggest that perhaps, these lower speed limits create a false sense of security for child pedestrians, in that they may be more likely to dart out in front of moving vehicles or take their time crossing a busy street.

In this study, over half of the incidents involved child pedestrians crossing the street and not using a crosswalk. Although a small percentage of the incidents involved child pedestrians using an assigned crosswalk, this study suggests that this does not necessarily mean that the child pedestrian was using the crosswalk properly. The incident reports do not state whether the child was crossing while the “walk” signal was flashing or while the light was green. This study suggests that the child's usage of the crosswalk needs to be considered. Conversely, the incidents involving child pedestrians not using crosswalks suggests that there is a need for crosswalk implementation and improvement in the study area. This study suggests that crosswalks should be installed in mid-block locations in many areas within the study area, such as in the area around Stone Mountain, examined in the walkability assessment. Also, crosswalk improvement should take place such that signals should be lengthened, allowing child pedestrians ample time to cross safely, and crosswalk buttons should be adjusted to change the light after a certain period of time. Furthermore, crosswalks around schools should be improved by installing them in safe locations, not in areas where there are view obstructions for the driver. These school crosswalks should also be raised and should incorporate some type of lighting and signal, rather than simply installing a sign that signifies the use of the crosswalk by school children.

A significant finding in this study is that, other than the location of schools playing a role in incident frequencies, the location of parks and greenspace within the study area also appear to contribute to incident frequency. The findings from this study suggest that in areas with dense clustering of incidents (incidents located within close proximity to other incidents) and areas with higher frequencies of incidents overall, schools, parks and recreation centers were found in most of the locations. This study found that although schools were located nearby, many incidents did not fall within the .5 miles buffer zone. However, many of these areas had incidents within close proximity to the location of many of Atlanta's pocket parks and neighborhood recreation centers. This suggests that these places create a place for school children to frequent, especially after school, thus, putting them at-risk of being involved in an incident as they travel to the park or recreation center.

Lastly, this study found that in many areas within the study area where clusters of incidents occurred, many of these incidents occurred on residential streets. Although schools and parks were located nearby, the incident locations were along residential streets that only contained homes. This study suggests that crosswalks, as well as, safe areas for children to play, such as additional parks and playlots should be installed in these areas in order to create safe places for these children to play.

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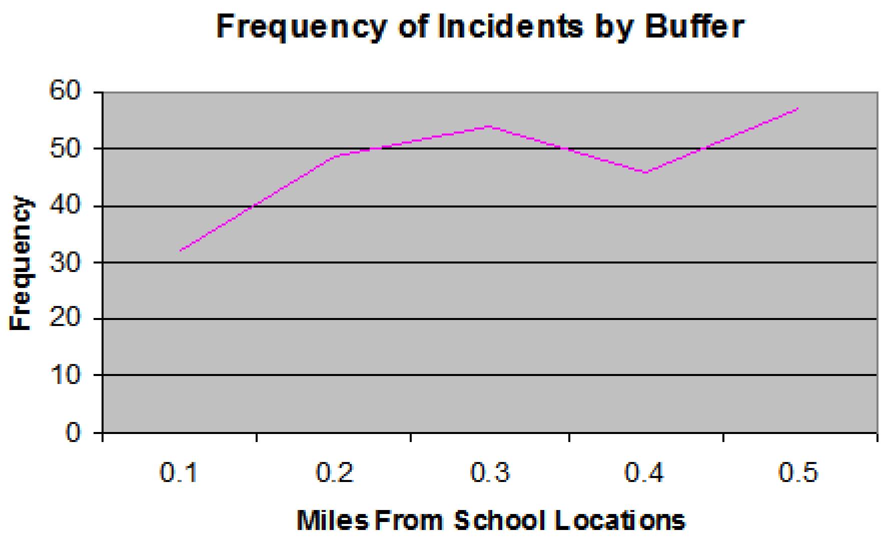
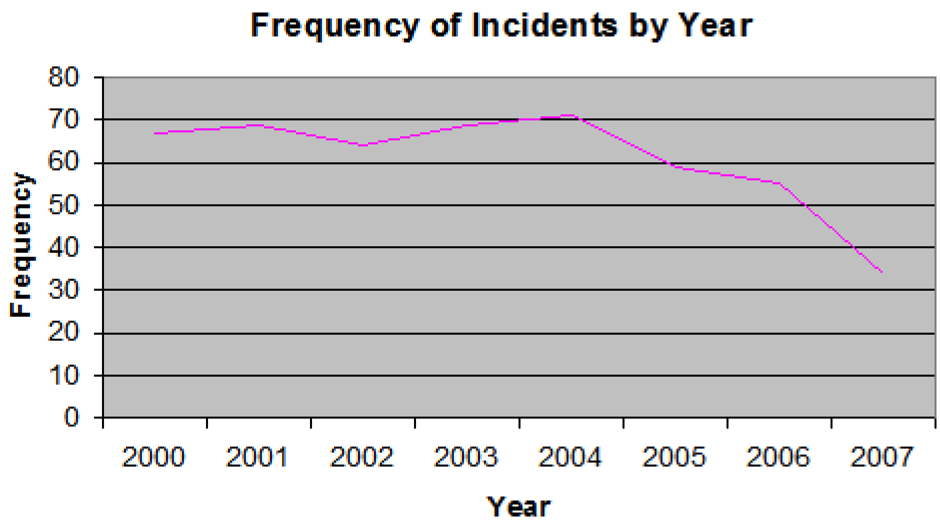
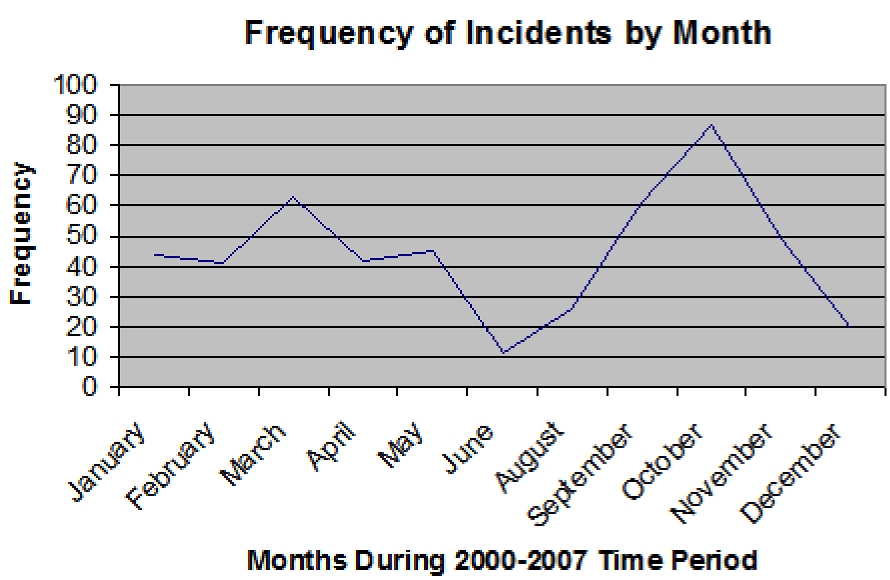
10 Appendix



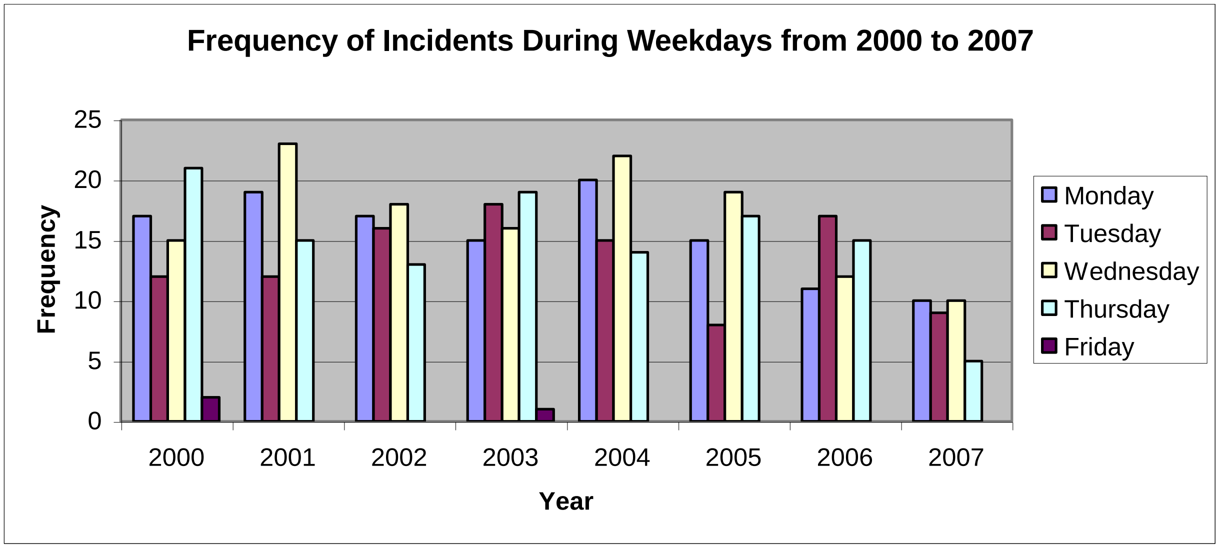
A. Incident Frequencies by Buffer: illustrating the total number of incidents occurring in each buffer zone.



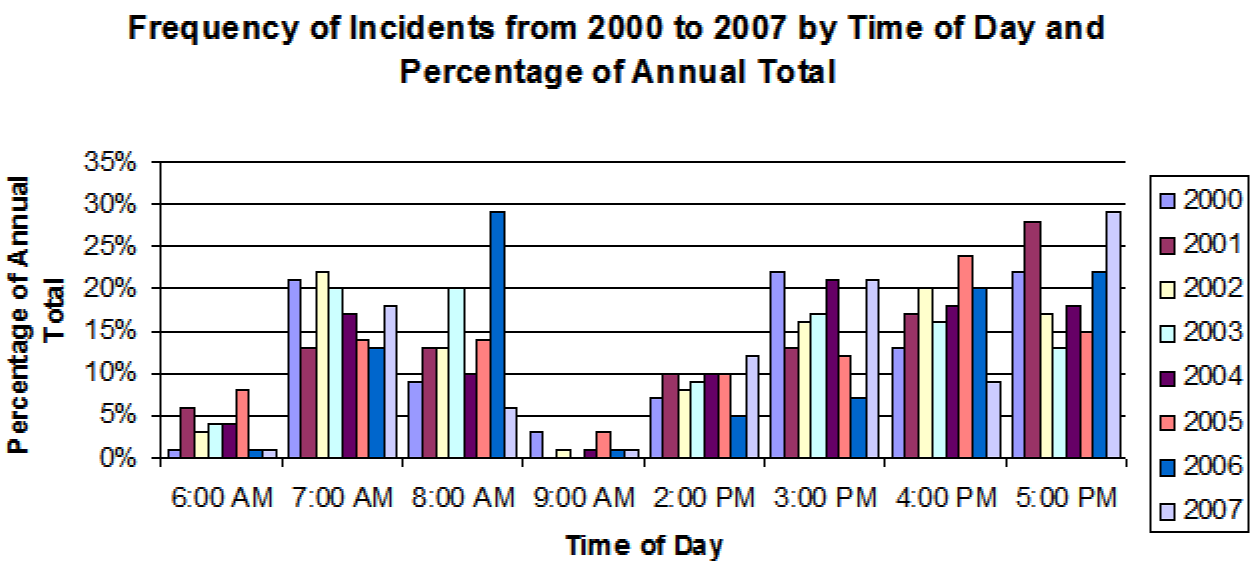
B. Frequency of Incidents by Year: illustrating the total number of incidents occurring each year from 2000 to 2007.



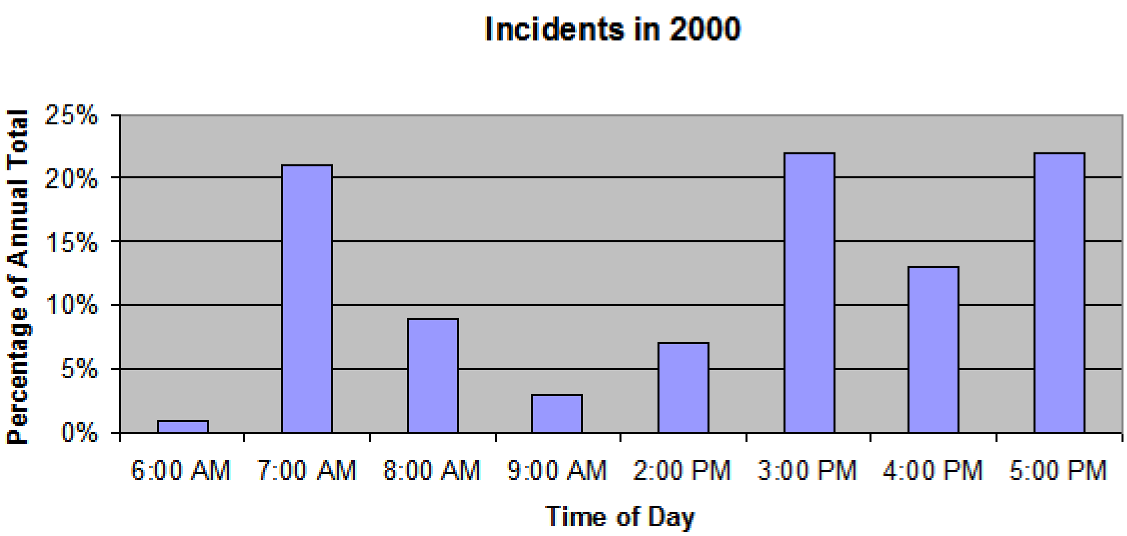
C. Frequency of incidents from 2000 to 2007 by month.



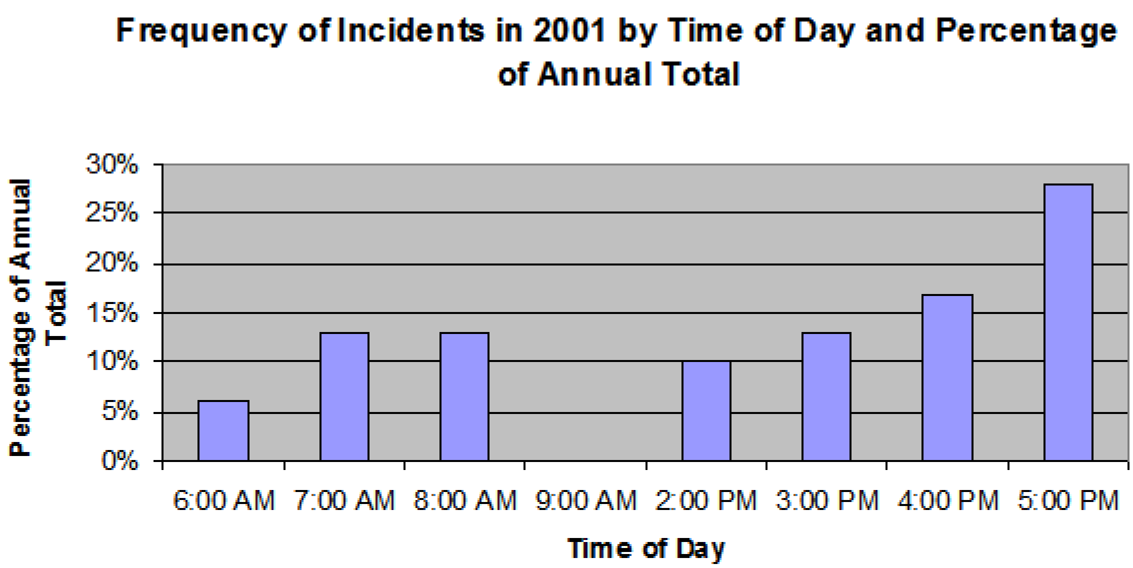
D. **Frequency of incidents from 2000 to 2007 by weekday.**



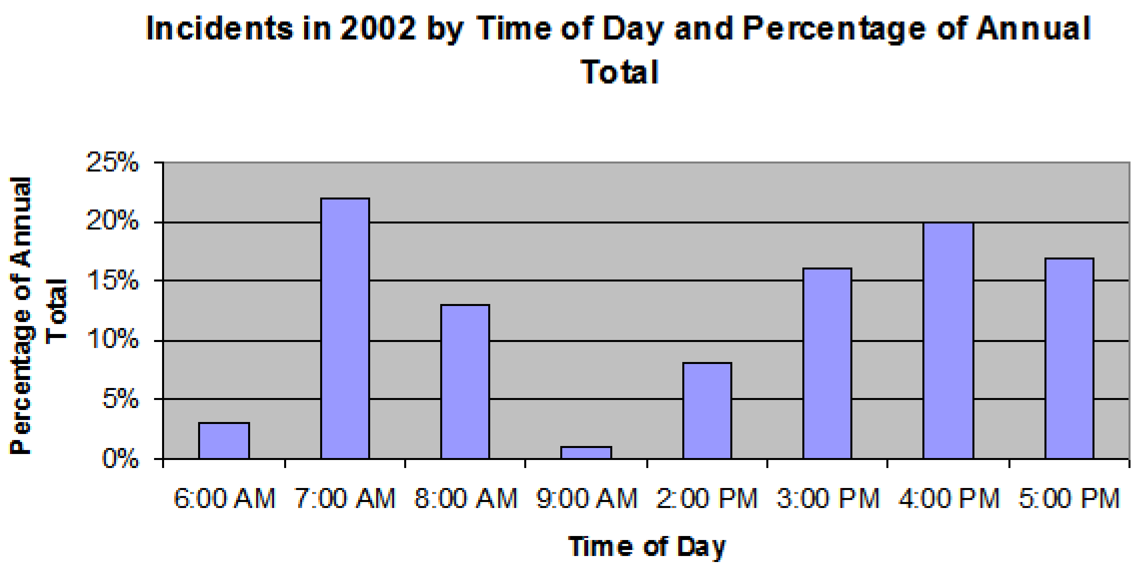
E. **Frequency of incidents from 2000 to 2007 by time of day and percentage of annual total that each time represents.**



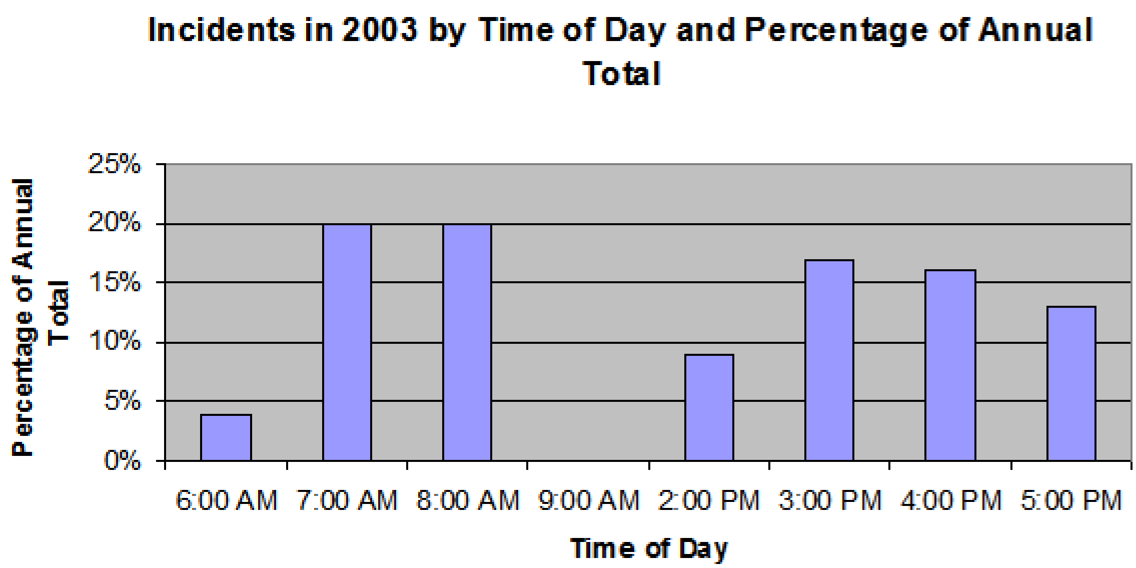
F. Frequency of incidents in 2000 by time of day and the percentage of the annual total that each time represents.



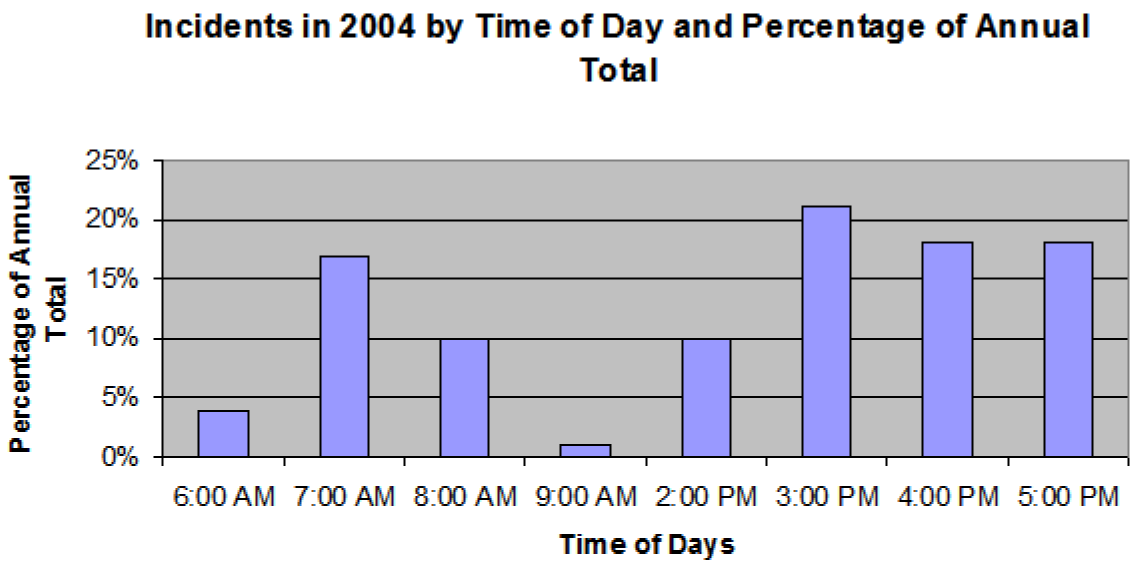
G. Frequency of incidents in 2001 by time of day and the percentage of annual total that each time represents.



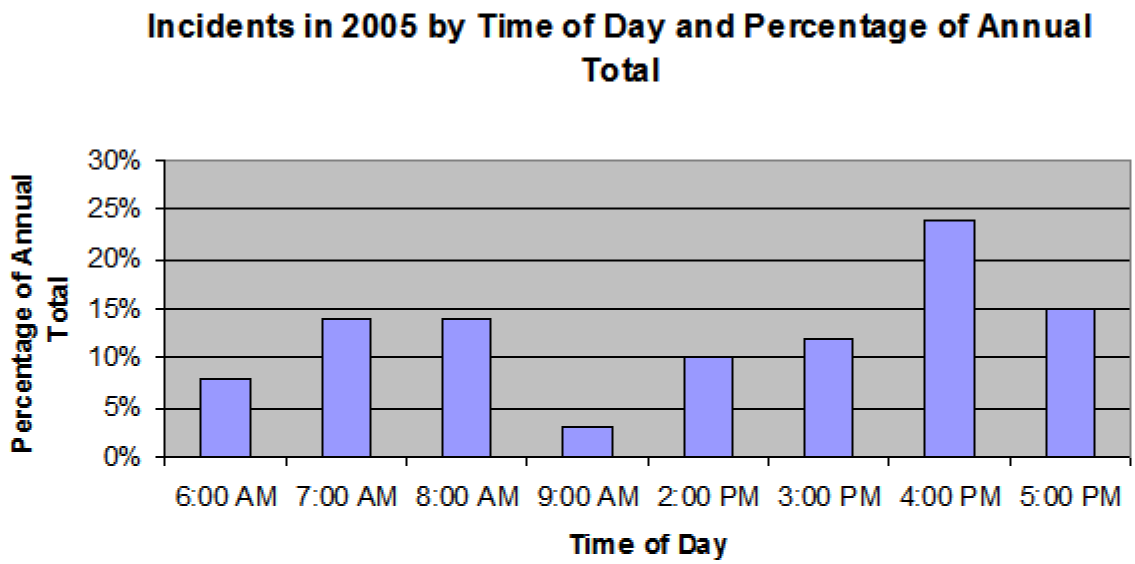
H. **Frequency of incidents in 2002 by time of day and the percentage of annual total that each time represents.**



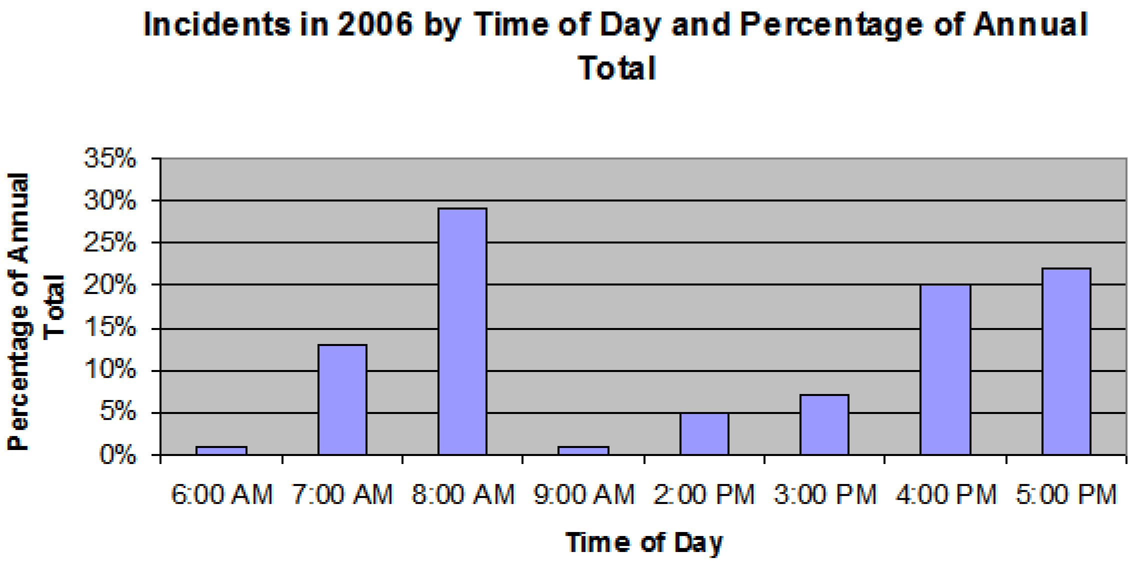
I. **Frequency of incidents in 2003 by time of day and the percentage of annual total that each time represents.**



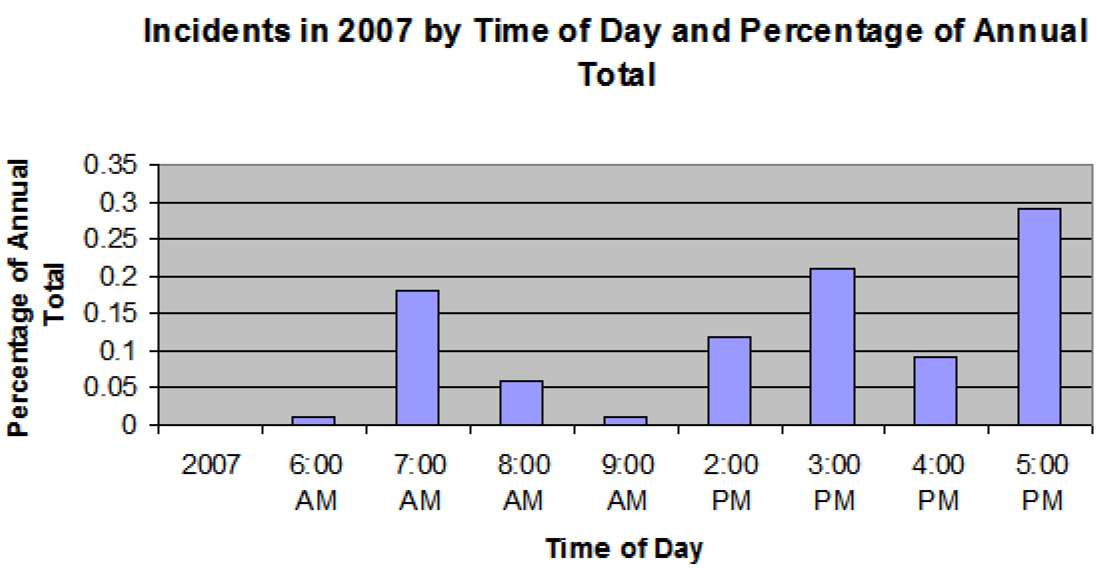
J. **Frequency of incidents in 2004 by time of day and the percentage of annual total that each time represents.**



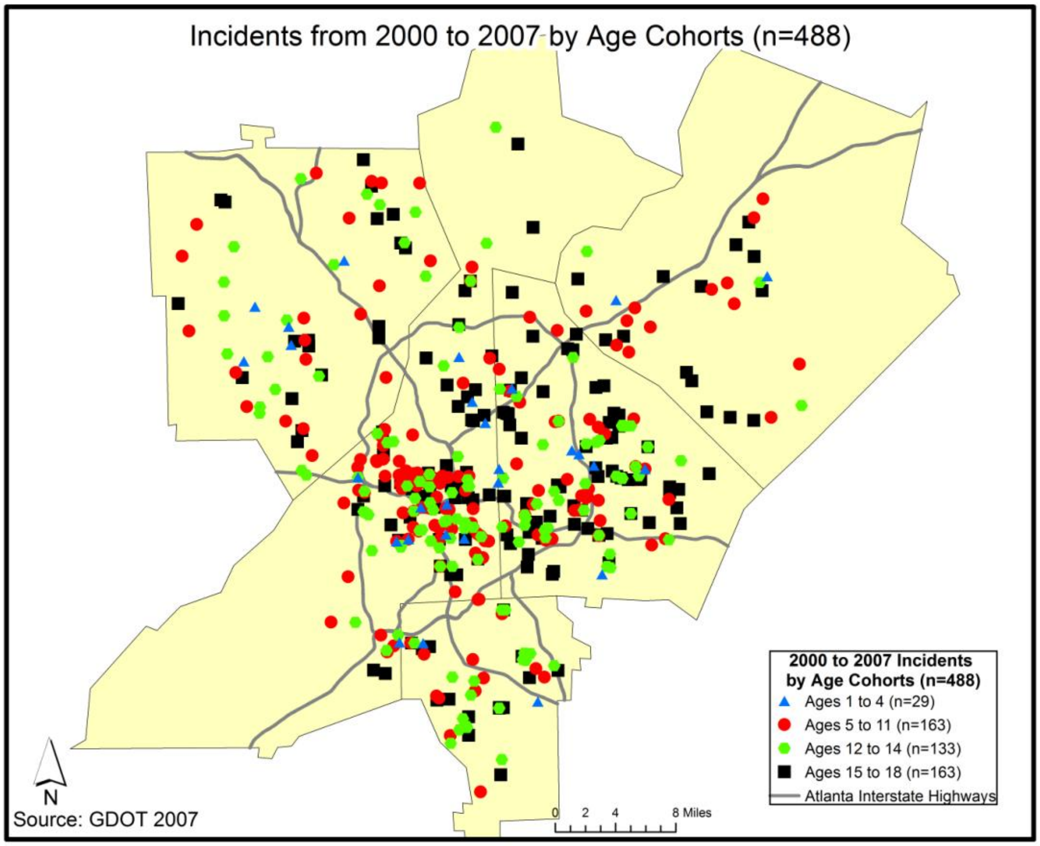
K. **Frequency of incidents in 2005 by time of day and the percentage of annual total that each time represents.**



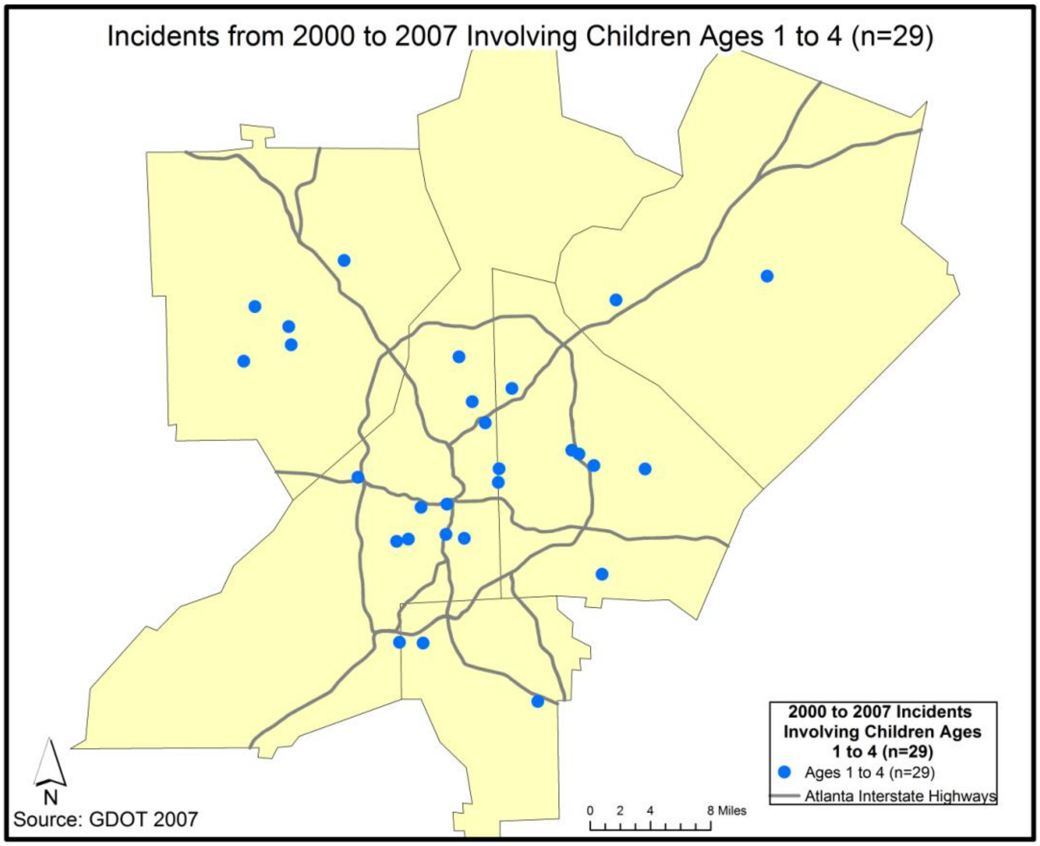
L. **Frequency of incidents in 2006 by time of day and the percentage of annual total that each time represents.**



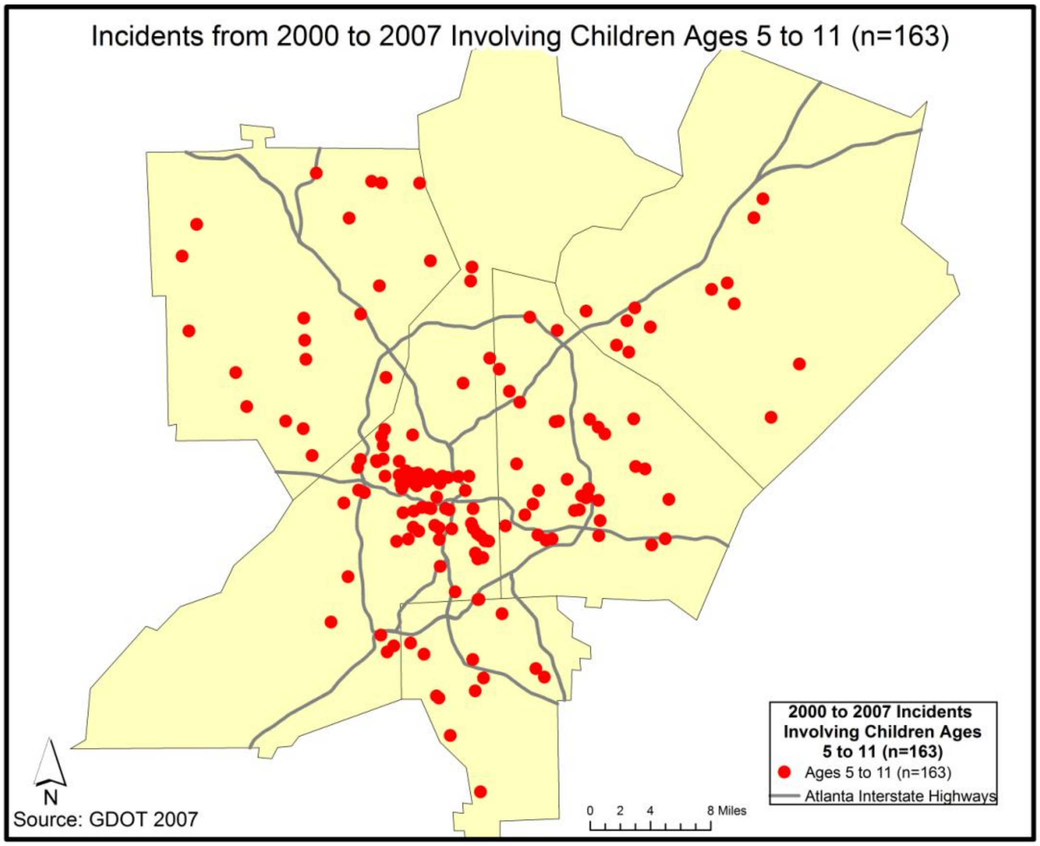
M. **Frequency of incidents in 2007 by time of day and the percentage of annual total that each time represents.**



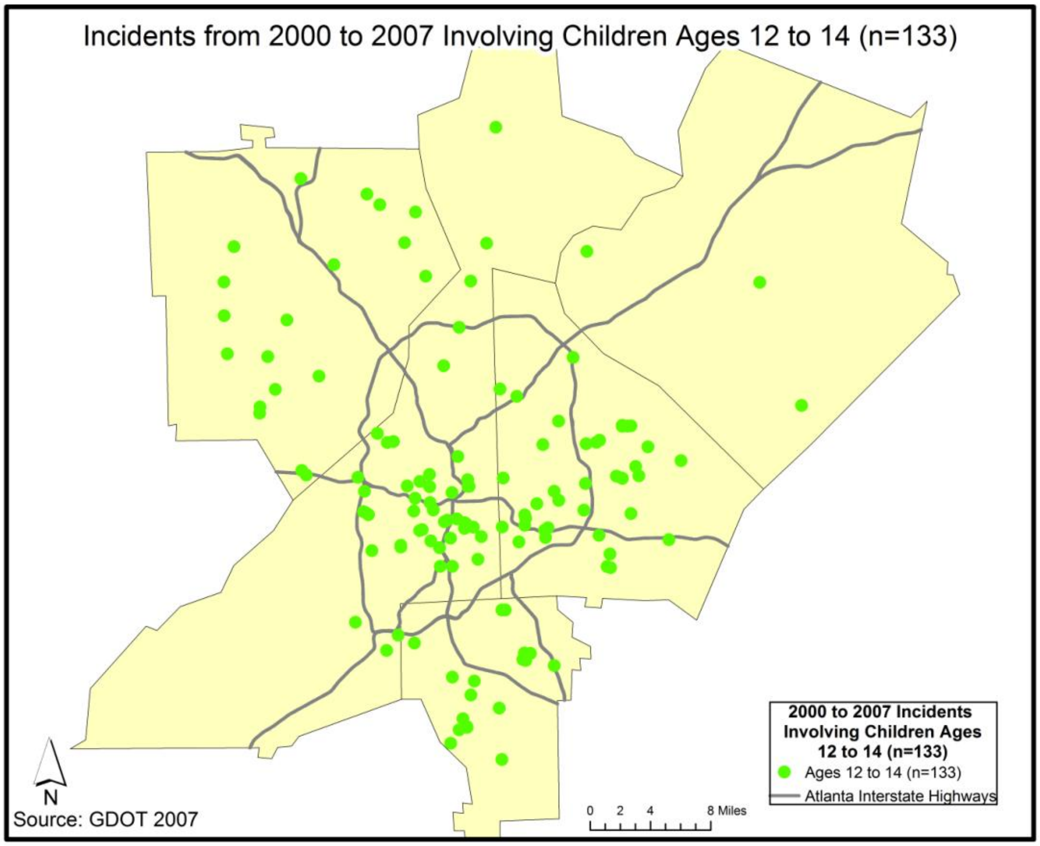
N. Total incidents from 2000 to 2007 by age cohorts



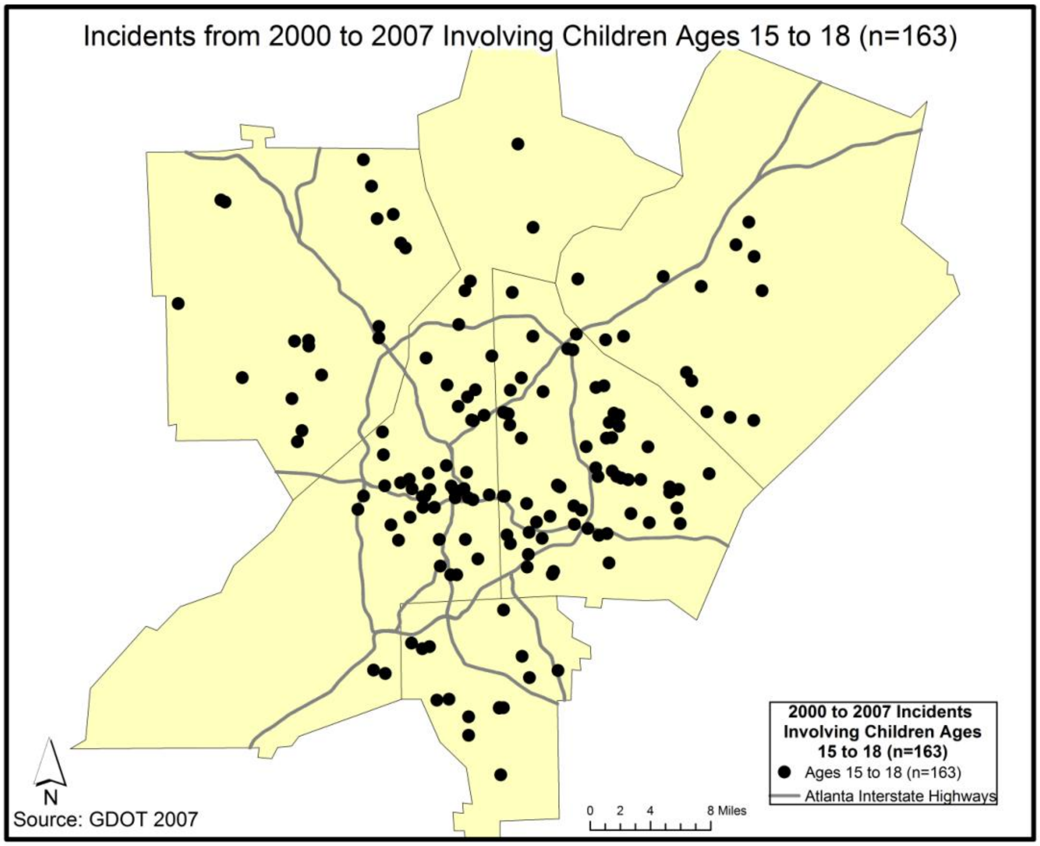
O. Total incidents from 2000 to 2007 involving children ages one to four



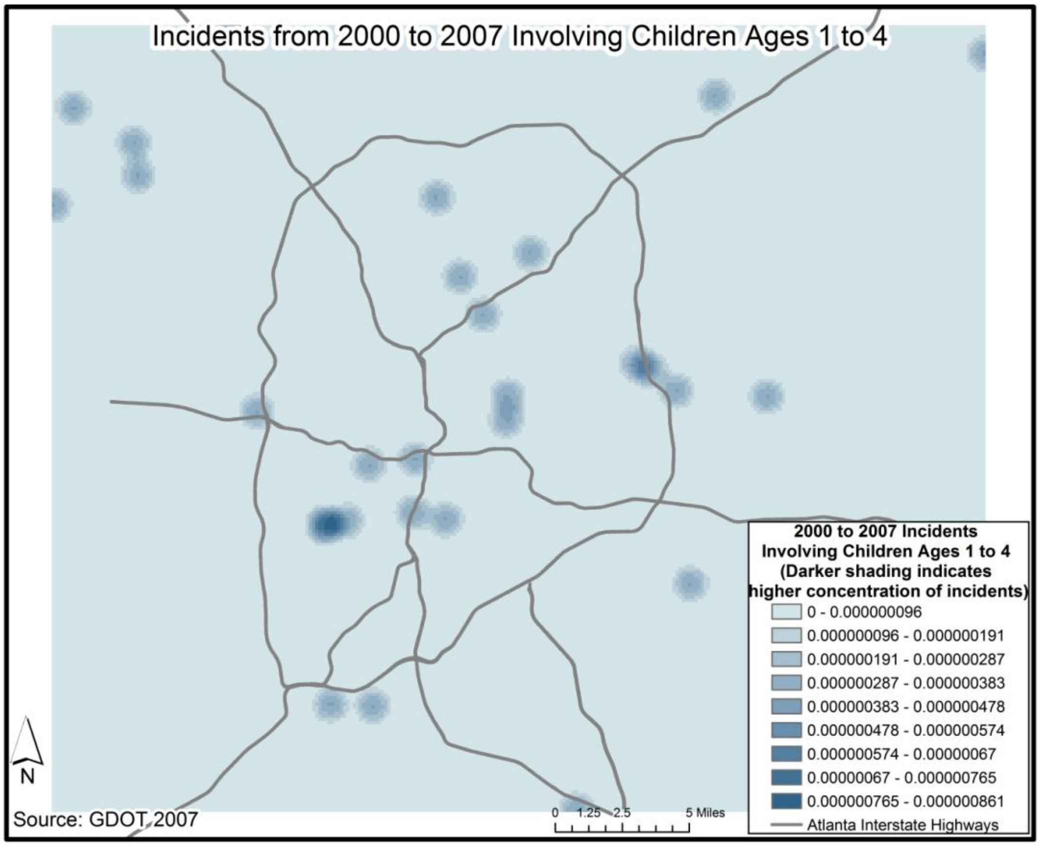
P. Incidents from 2000 to 2007 involving children ages five to 11



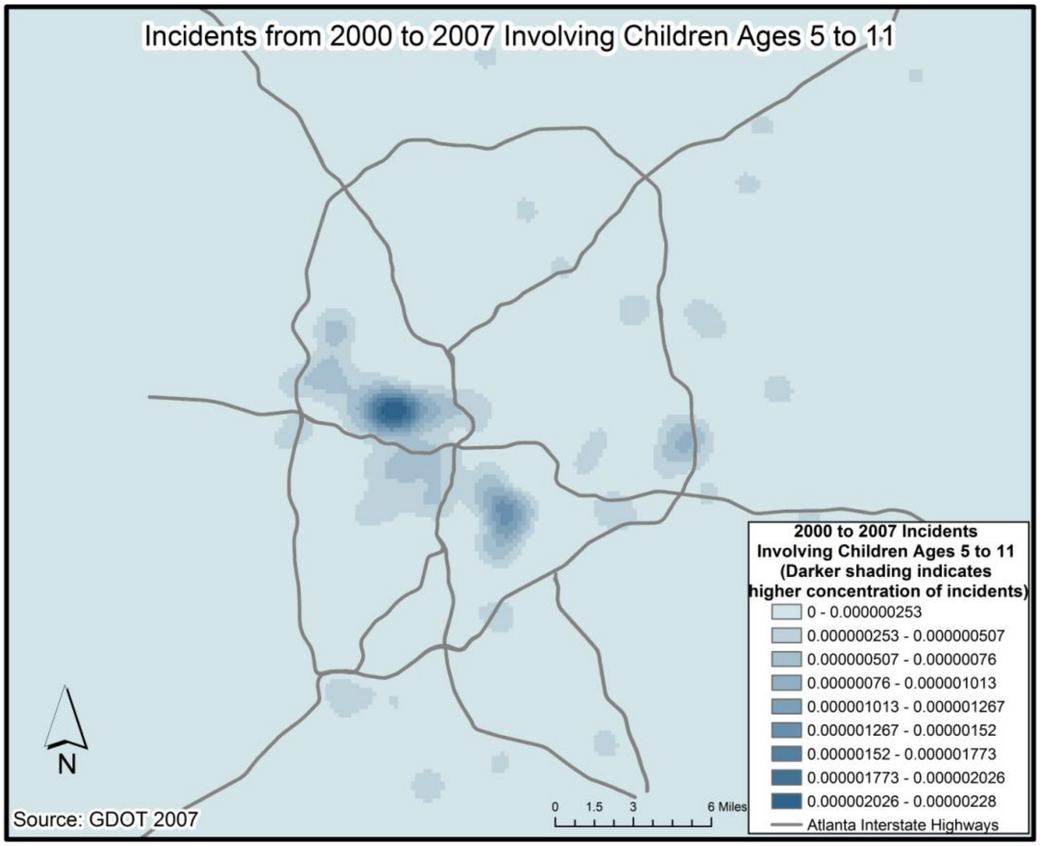
Q. Incidents from 2000 to 2007 involving children ages 12 to 14



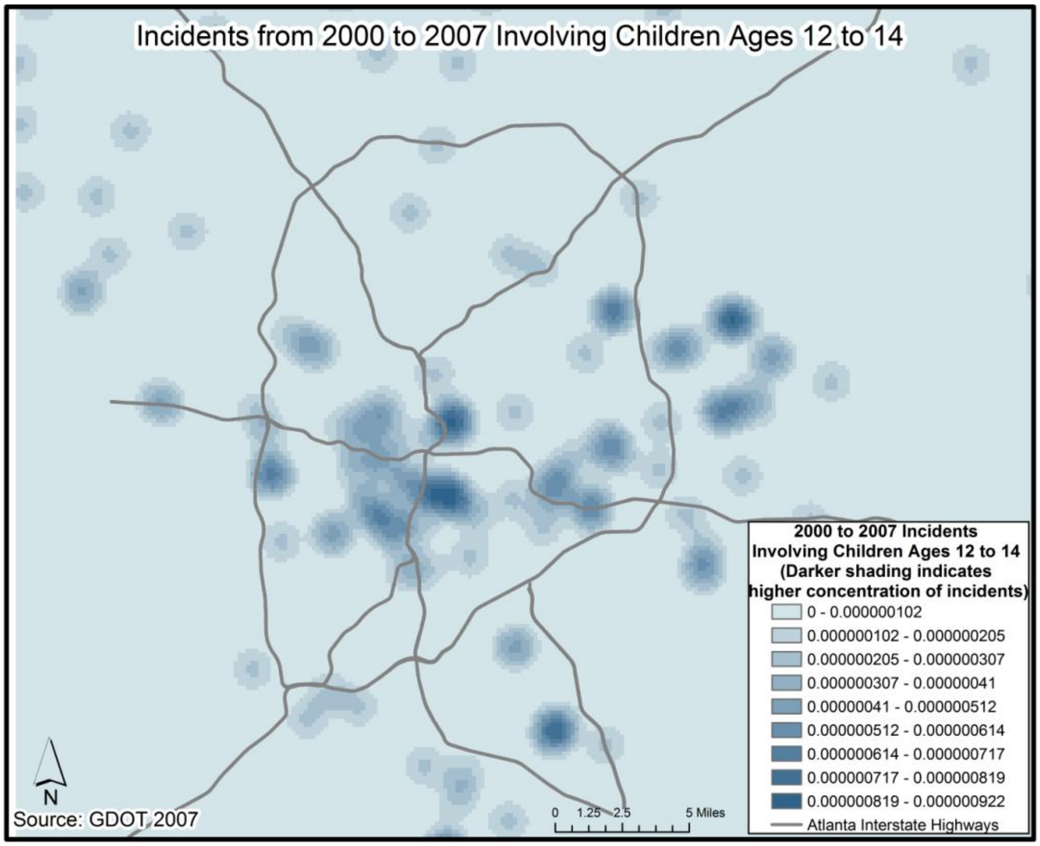
R. Incidents from 2000 to 2007 involving children ages 15 to 18



S. Incidents from 2000 to 2007 involving children ages one to four. Darker shading indicates higher concentration of incidents per square mile.



T. Incidents from 2000 to 2007 involving children ages five to 11. Darker shading indicates higher concentration of incidents per square mile.



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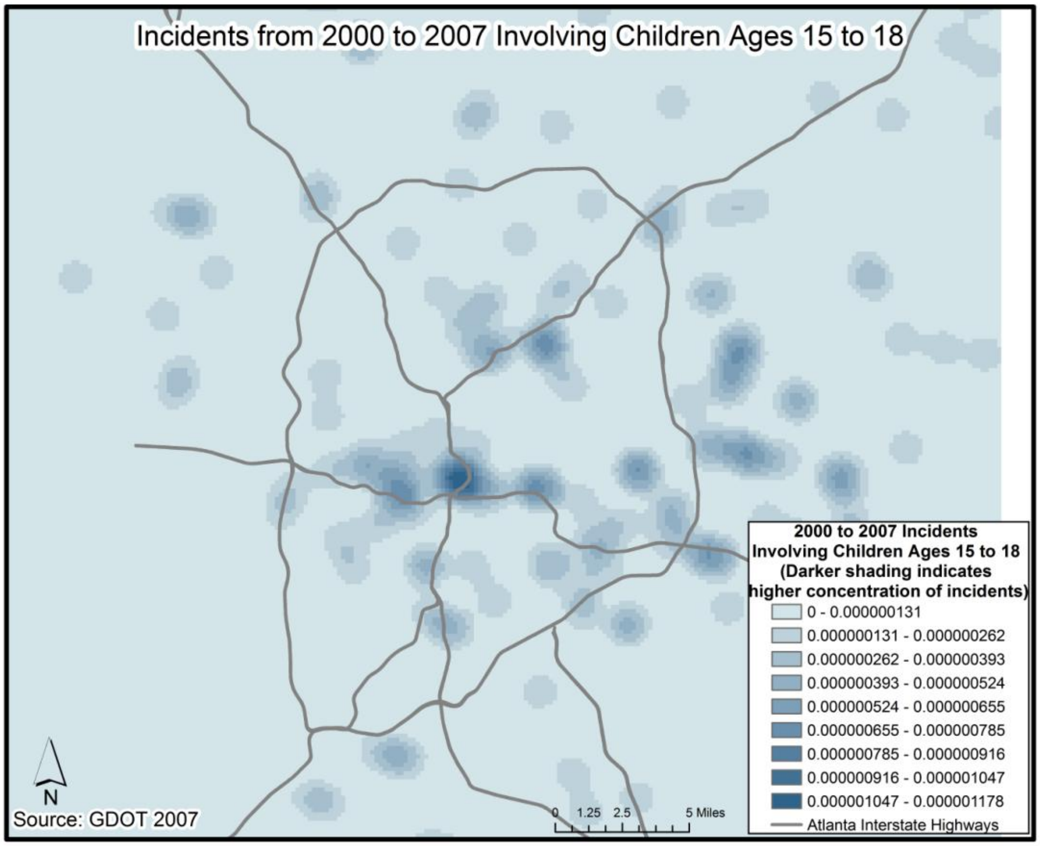

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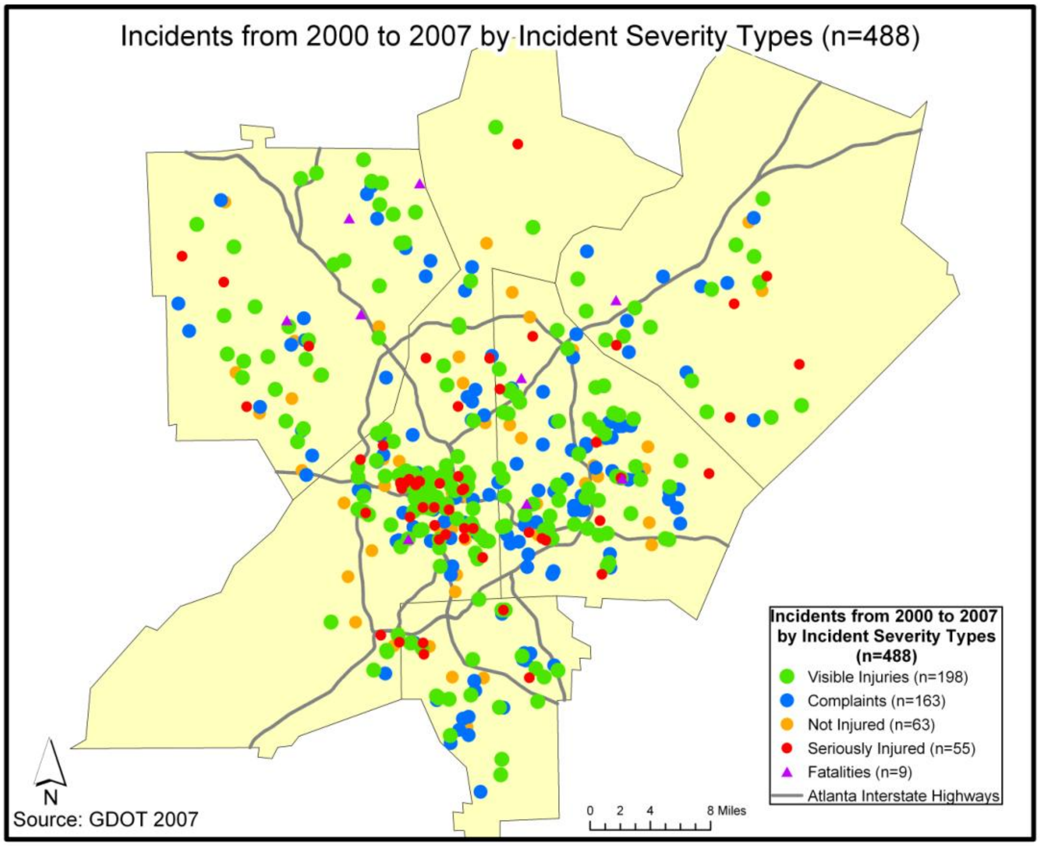
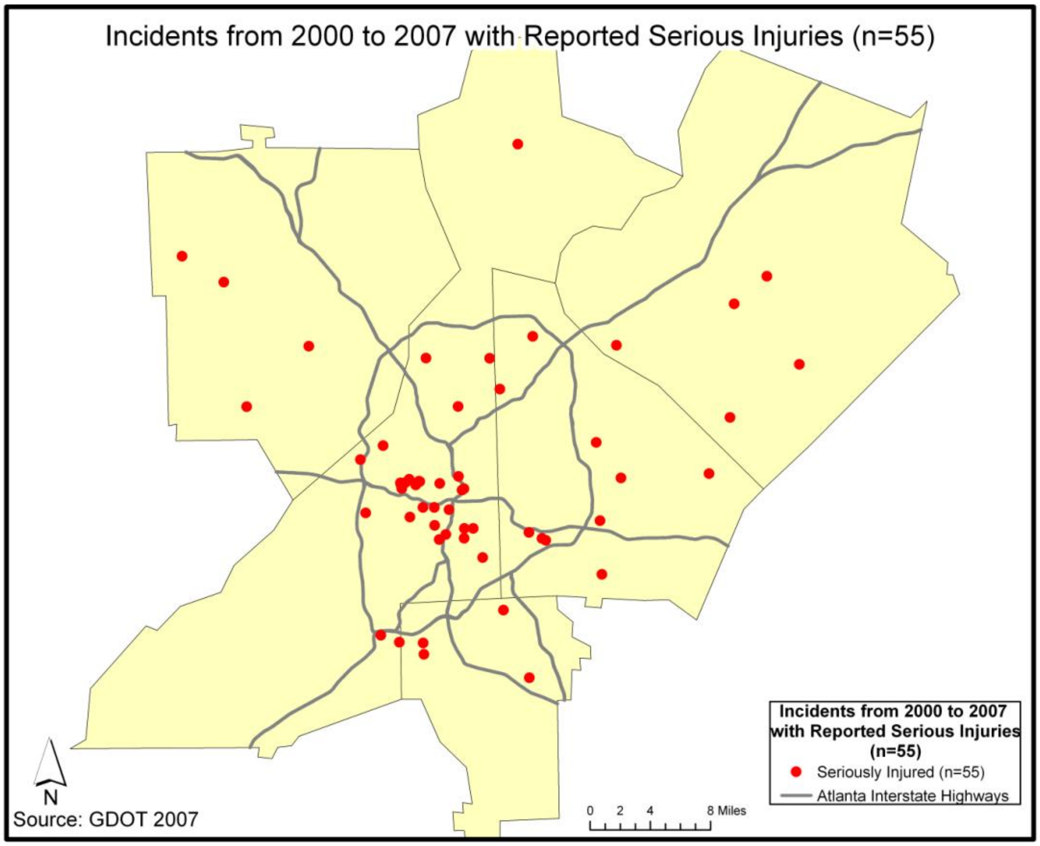
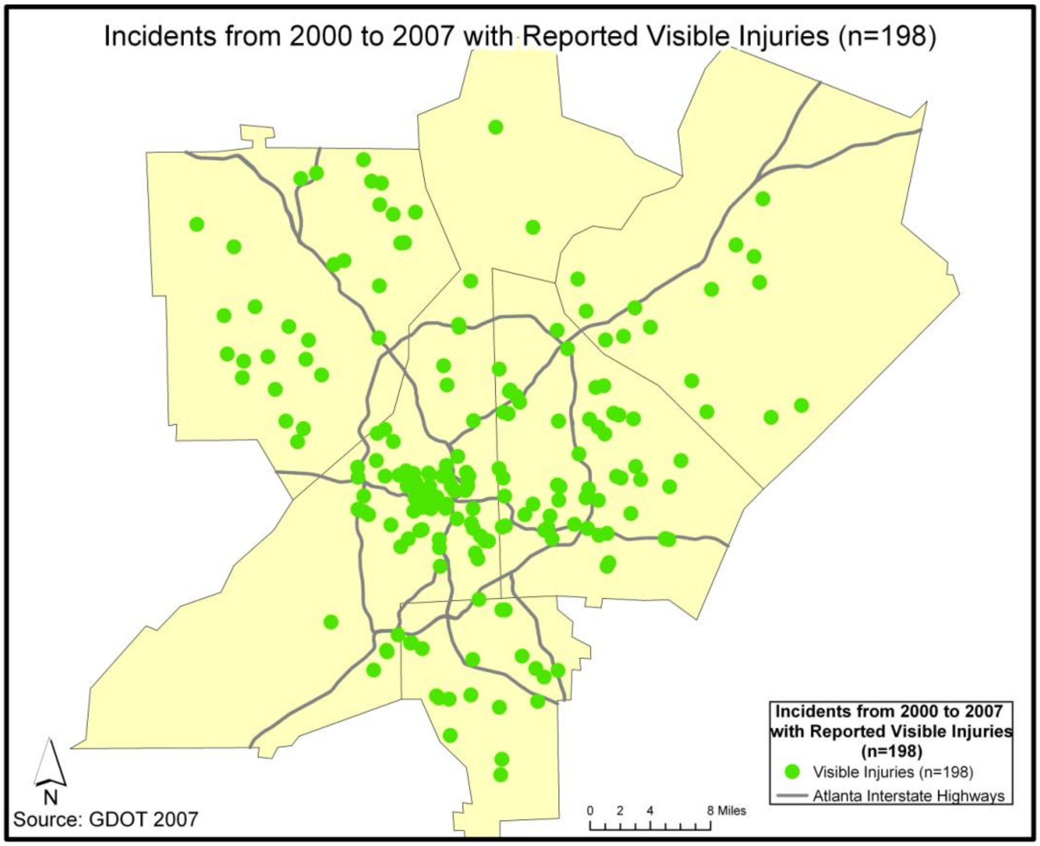


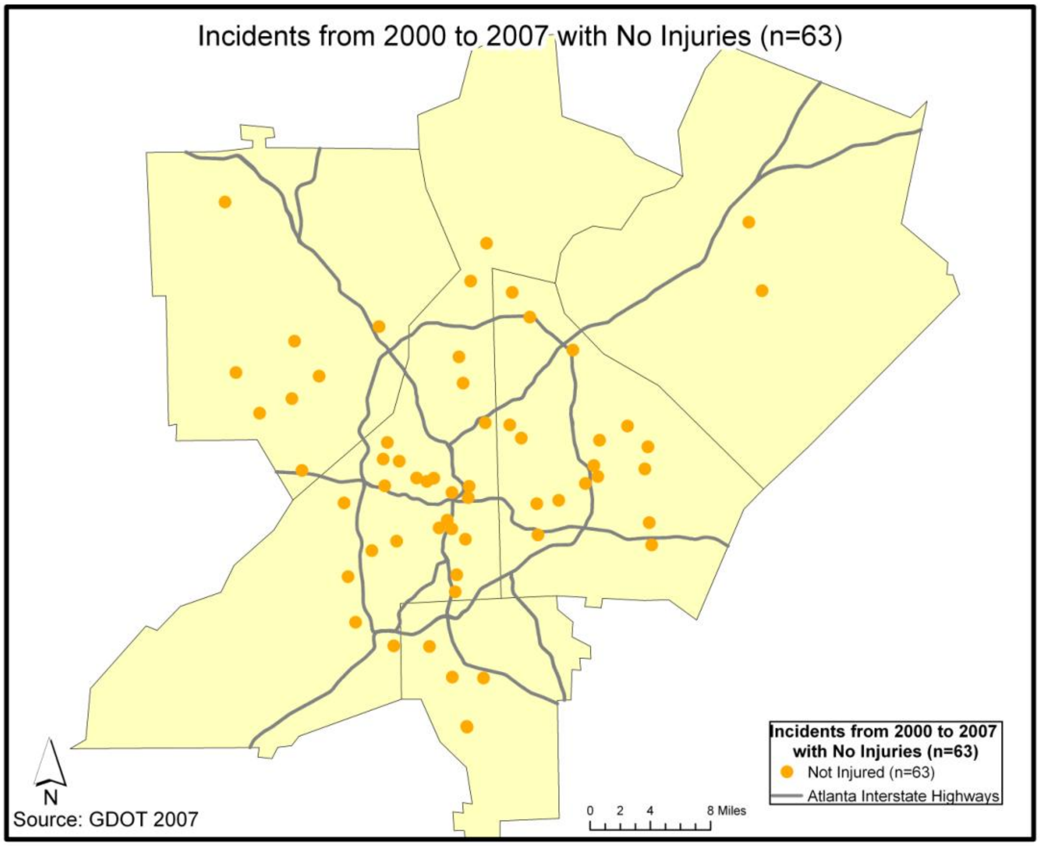
W. Incidents from 2000 to 2007 by incident severity types



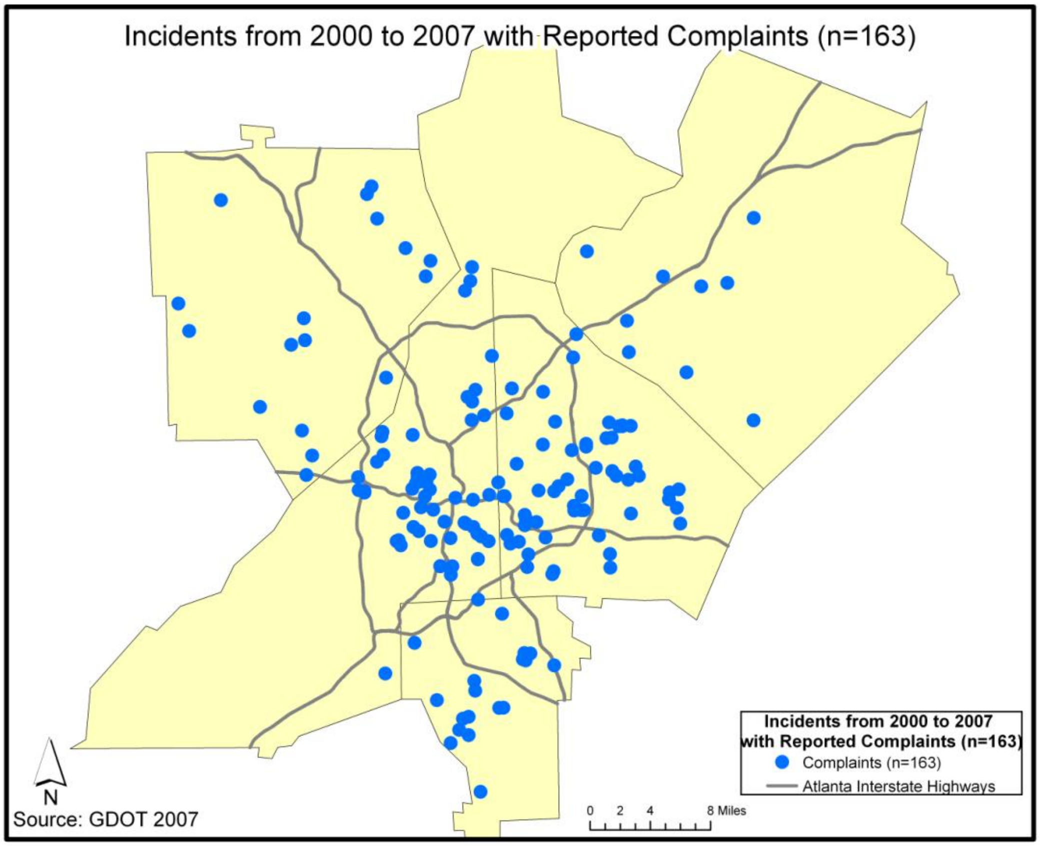
X. Incidents from 2000 to 2007 with reported serious injuries



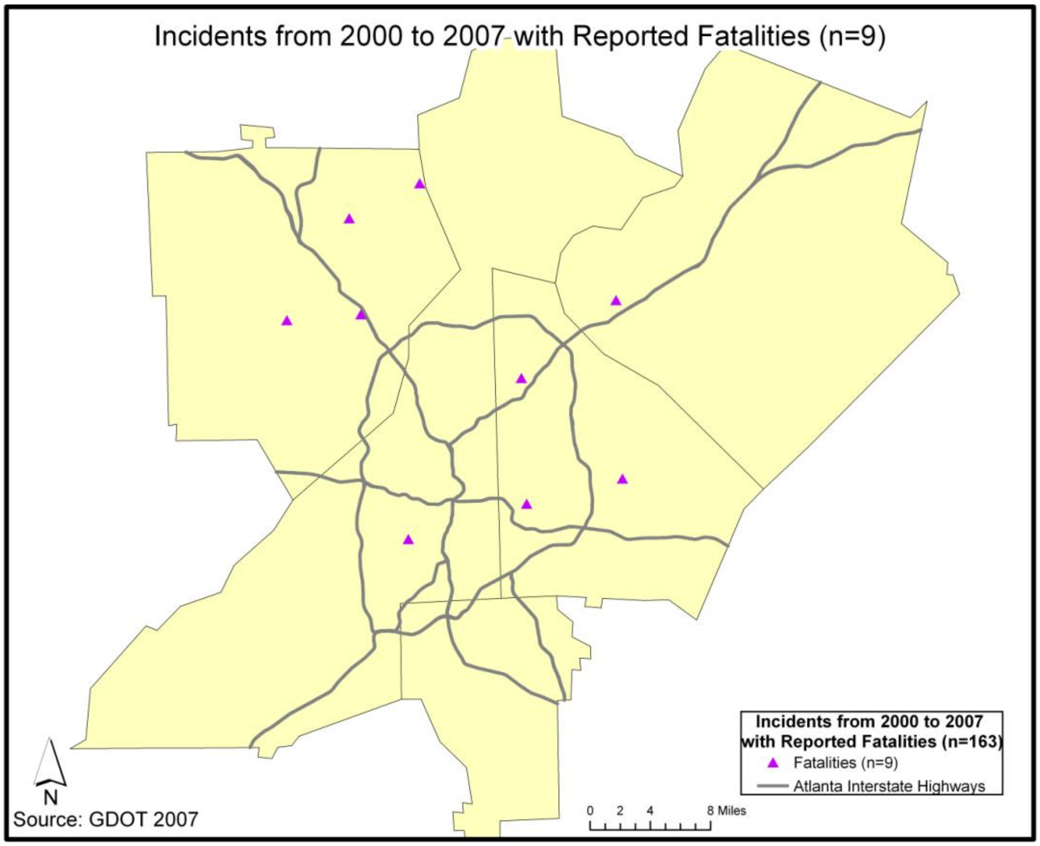
Y. Incidents from 2000 to 2007 with reported visible injuries



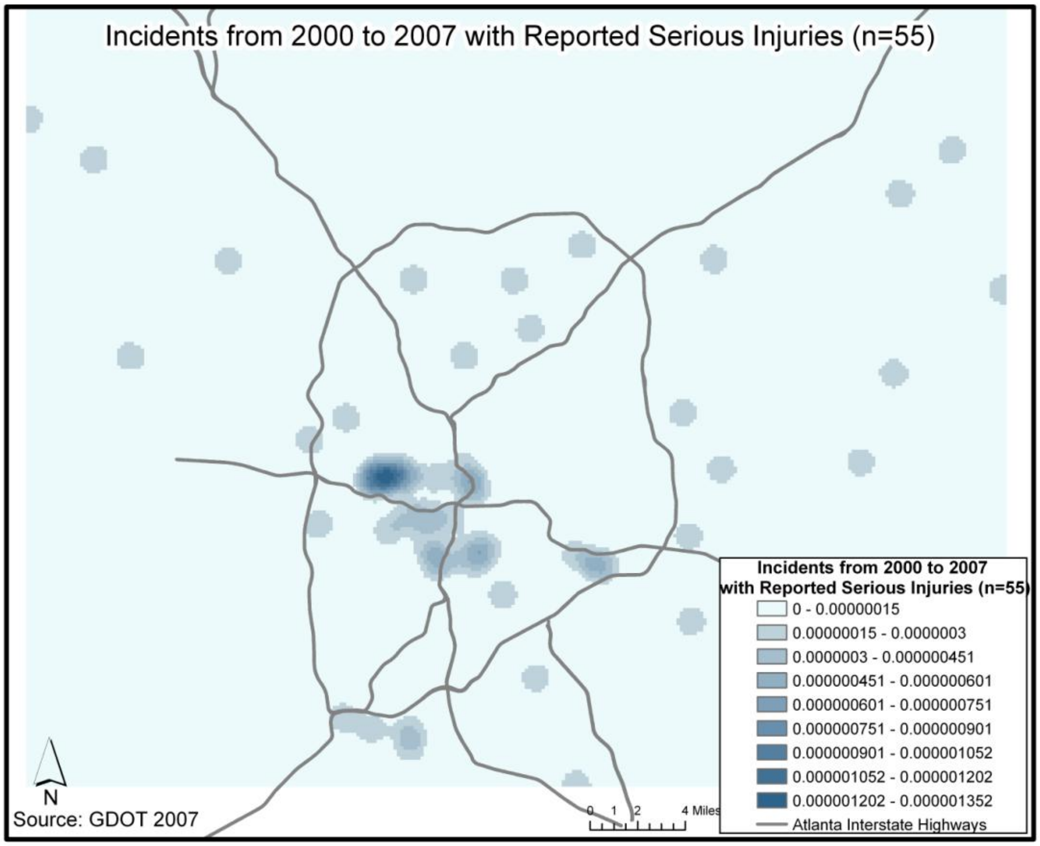
Z. Incidents from 2000 to 2007 with no reported injuries



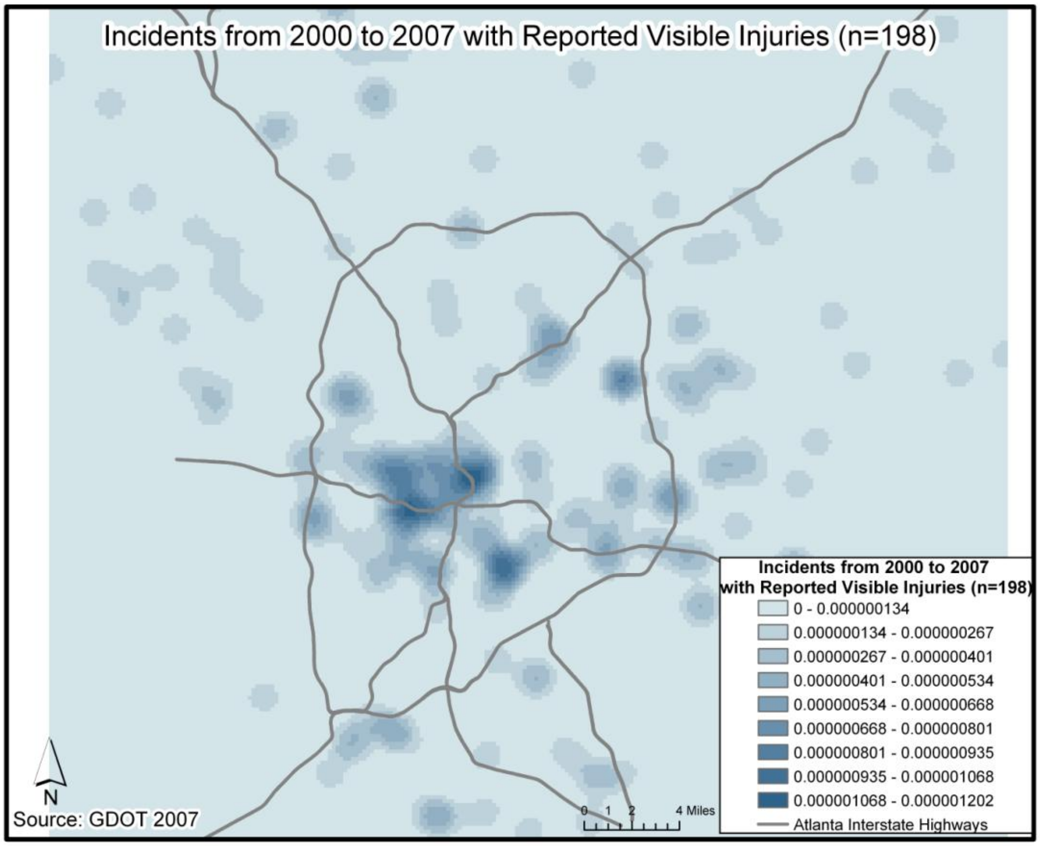
AA. Incidents from 2000 to 2007 with reported complaints



AB. Incidents from 2000 to 2007 with reported fatalities



AC. Kernel density map displaying incidents from 2000 to 2007 with reported serious injuries. Darker shading indicates higher concentration of incidents per square mile.



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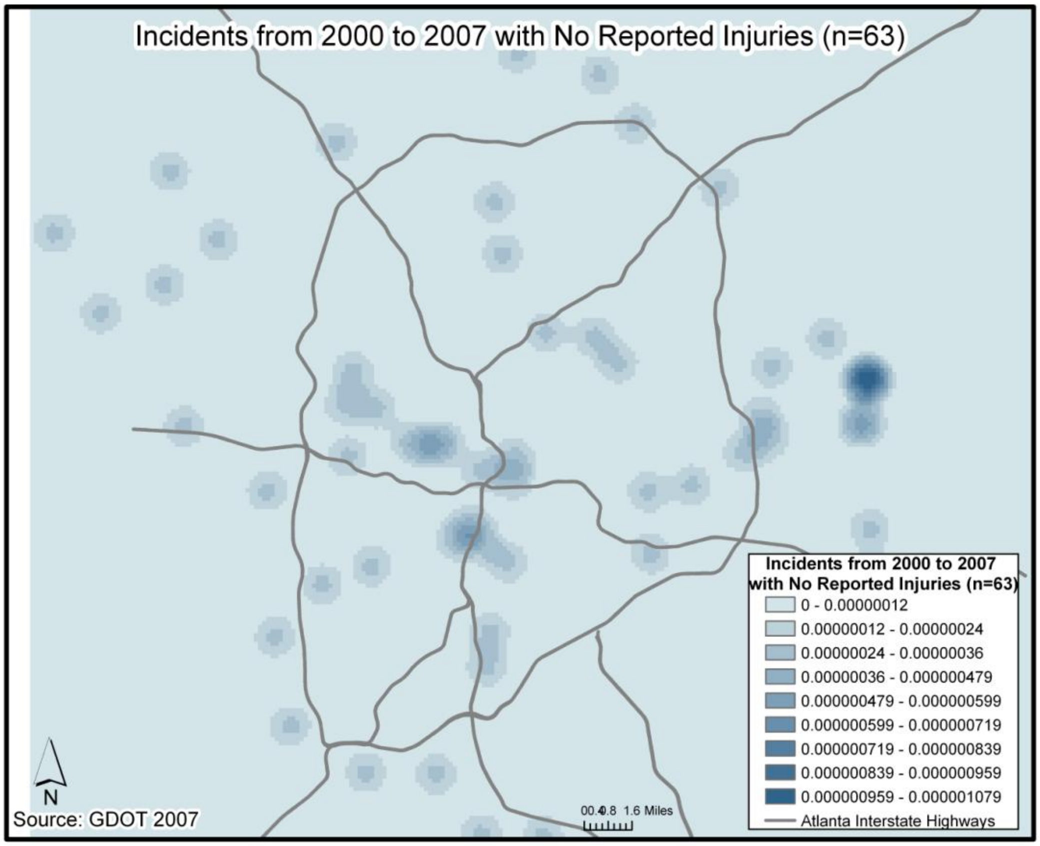
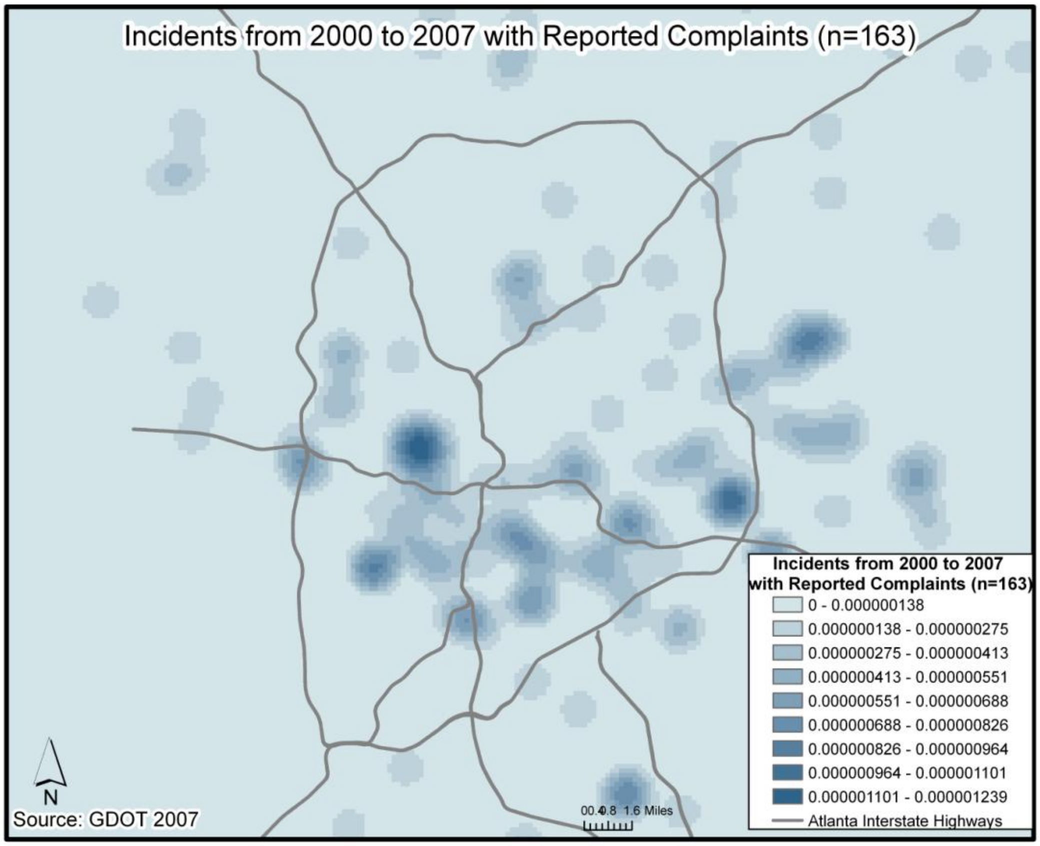
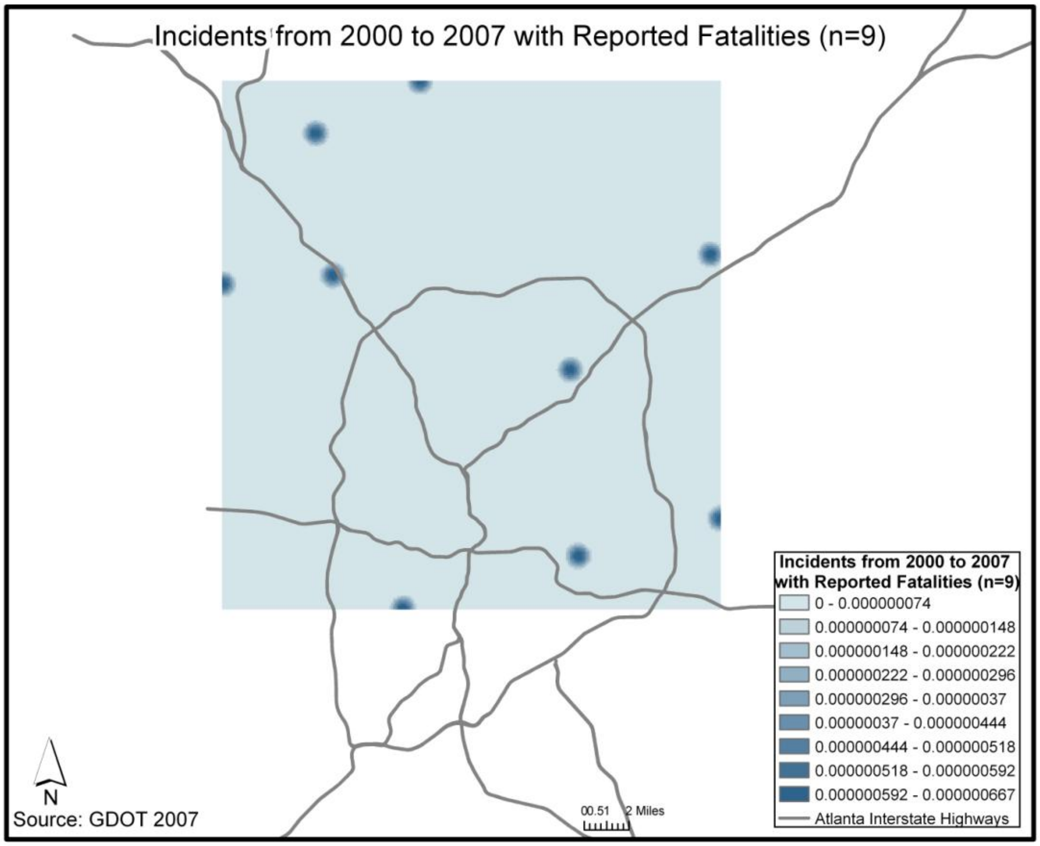


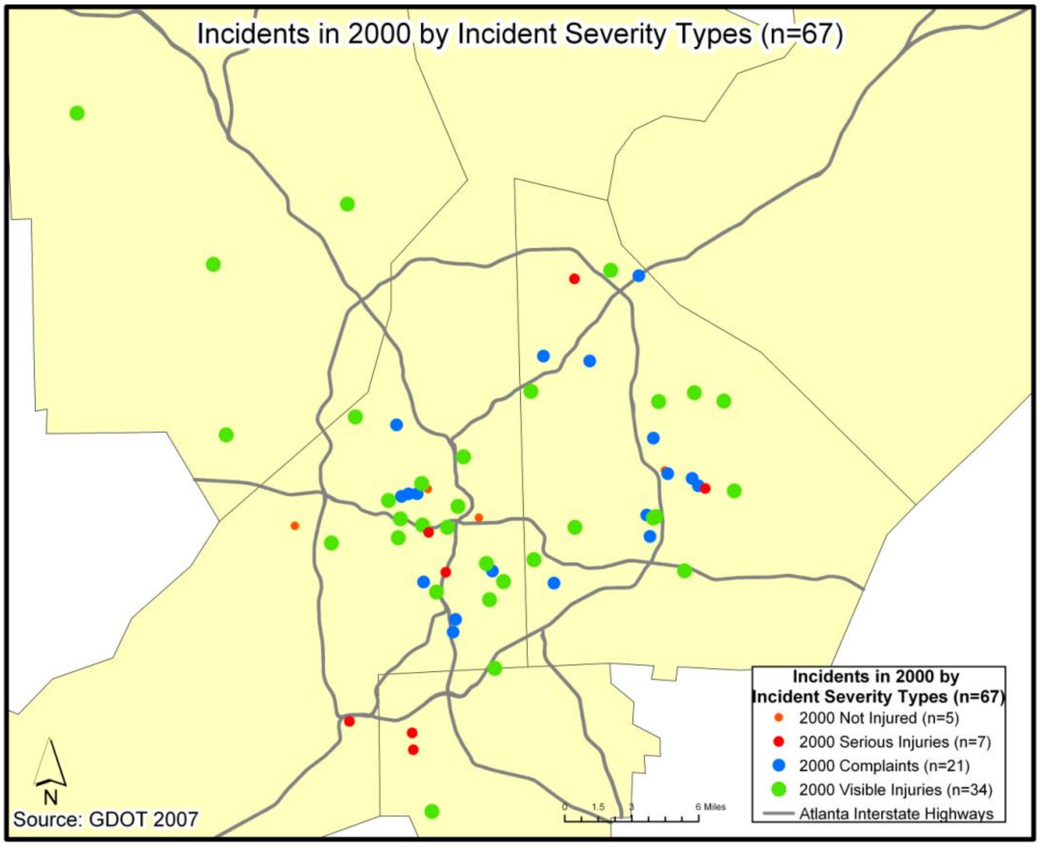
AE. Kernel density map displaying incidents from 2000 to 2007 with no reported injuries. Darker shading indicates higher concentration of incidents per square mile.



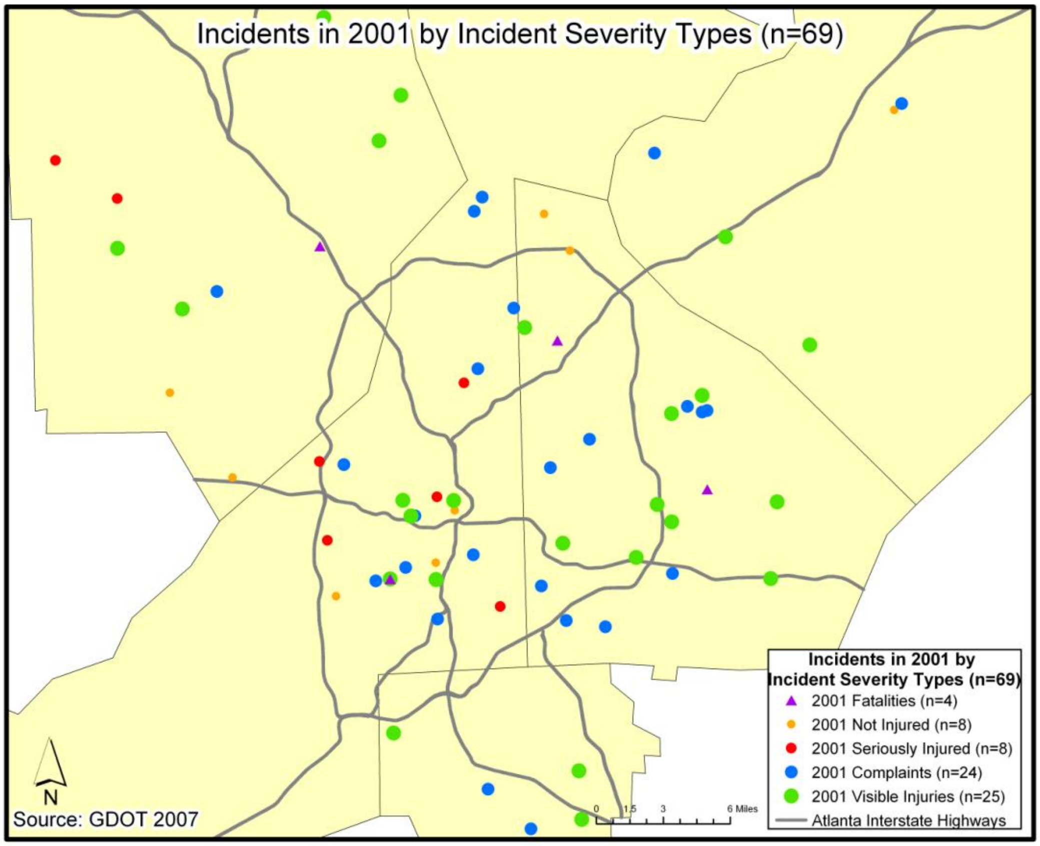
AF. Kernelkernel density map displaying incidents from 2000 to 2007 with reported complaints. Darker shading indicates higher concentration of incidents per square mile.



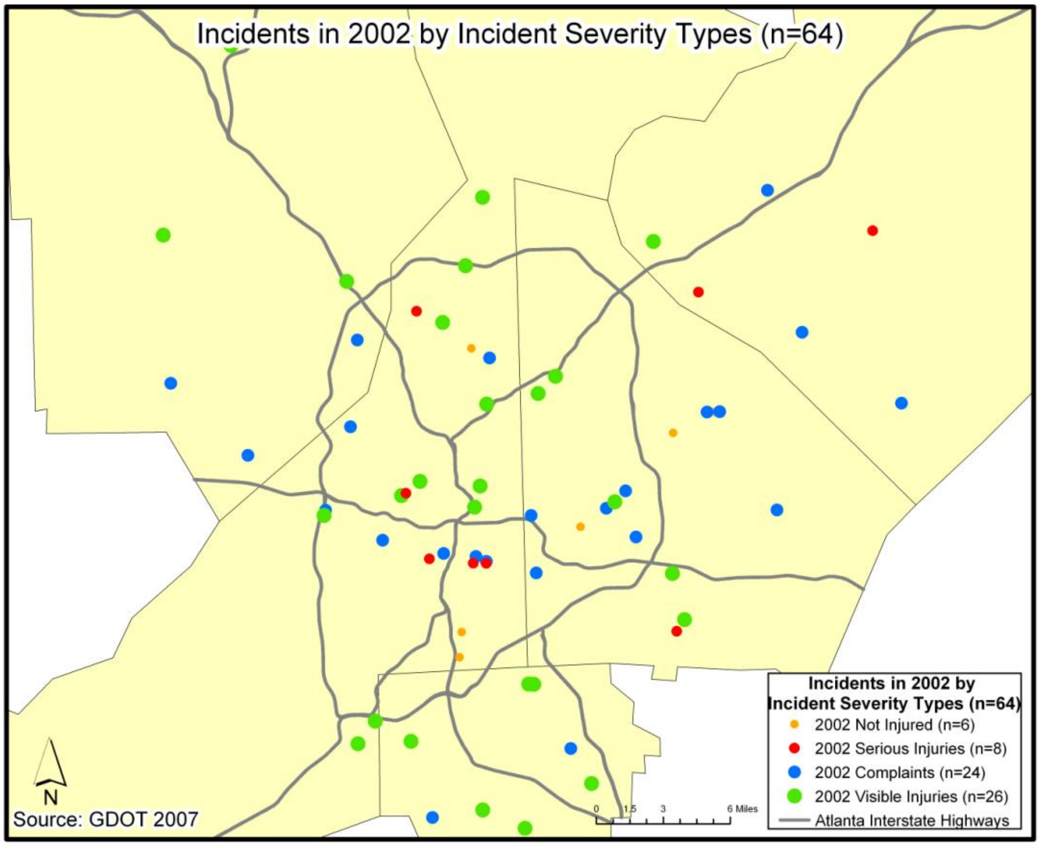
AG. Kernel density map displaying incidents from 2000 to 2007 with reported fatalities. Darker shading indicates higher concentration of incidents per square mile.



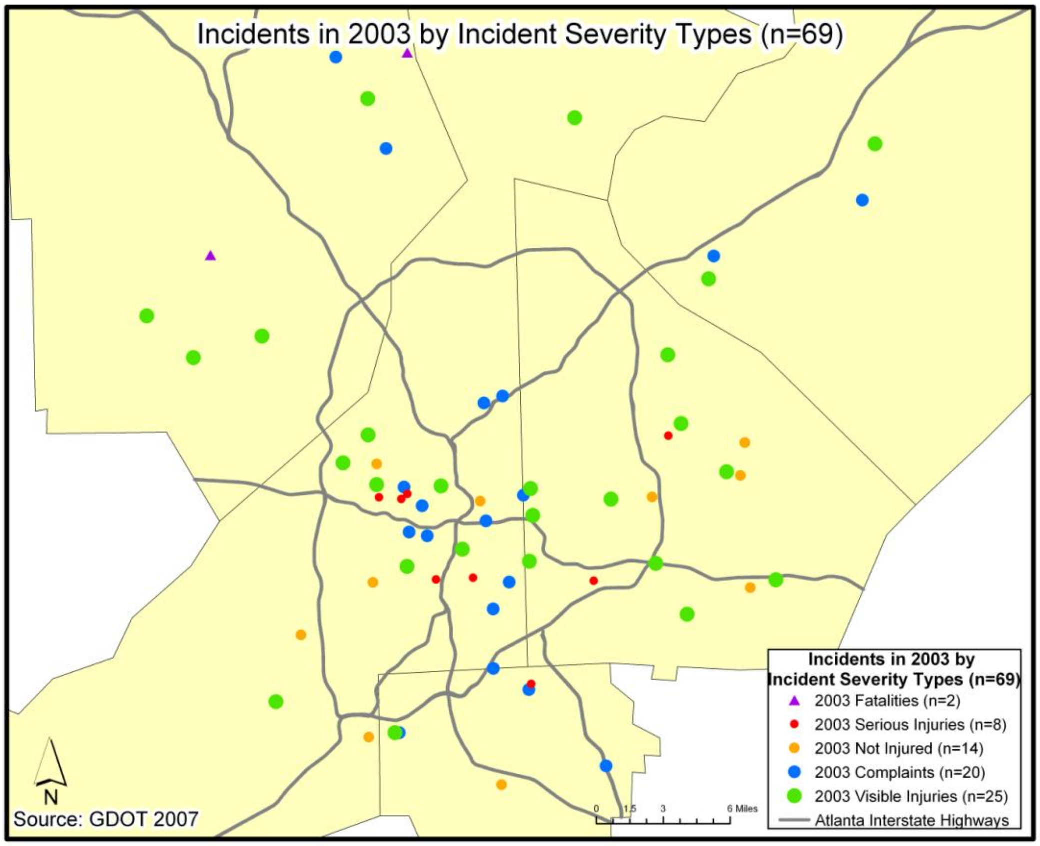
AH. Incidents in 2000 by incident severity types



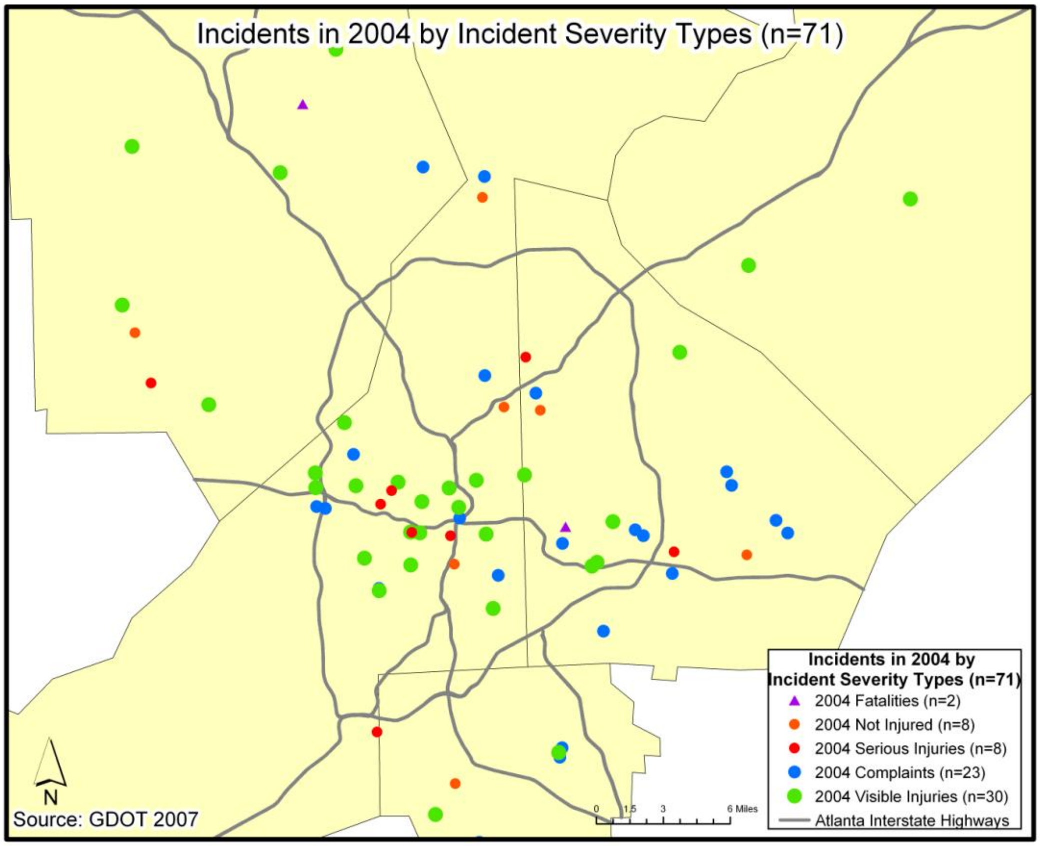
AI. Incidents in 2001 by severity types



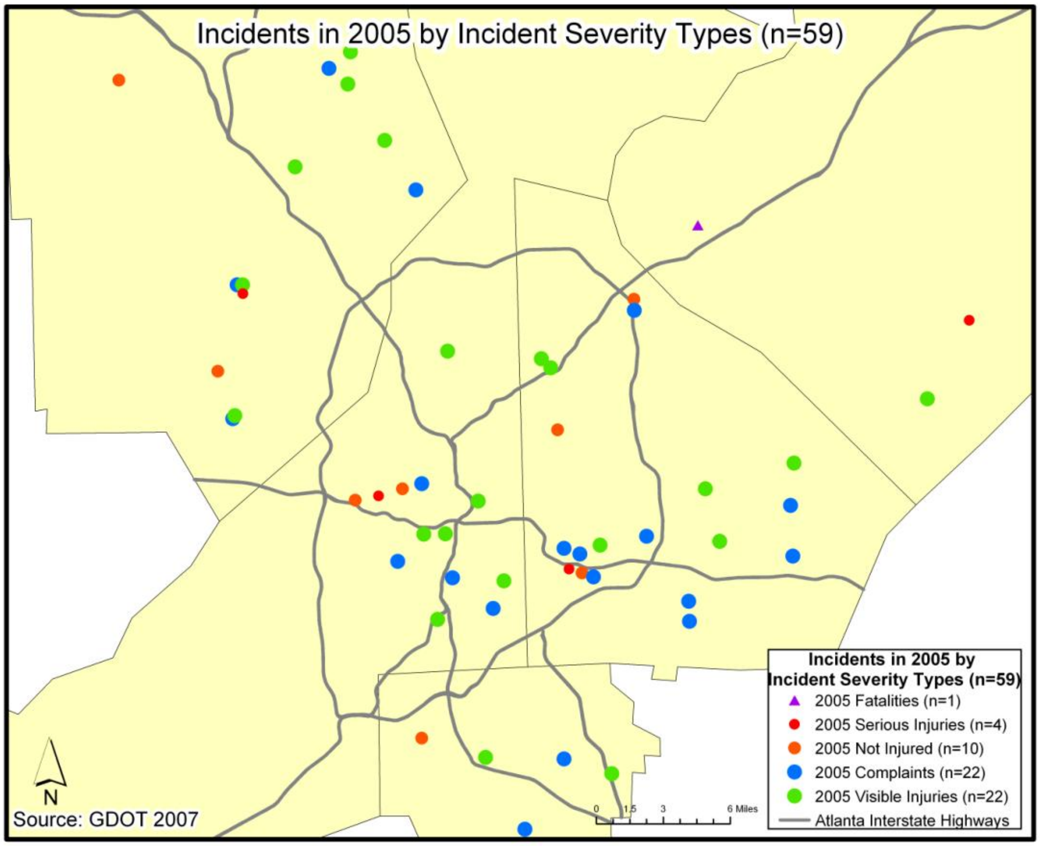
AJ. Incidents in 2002 by severity types



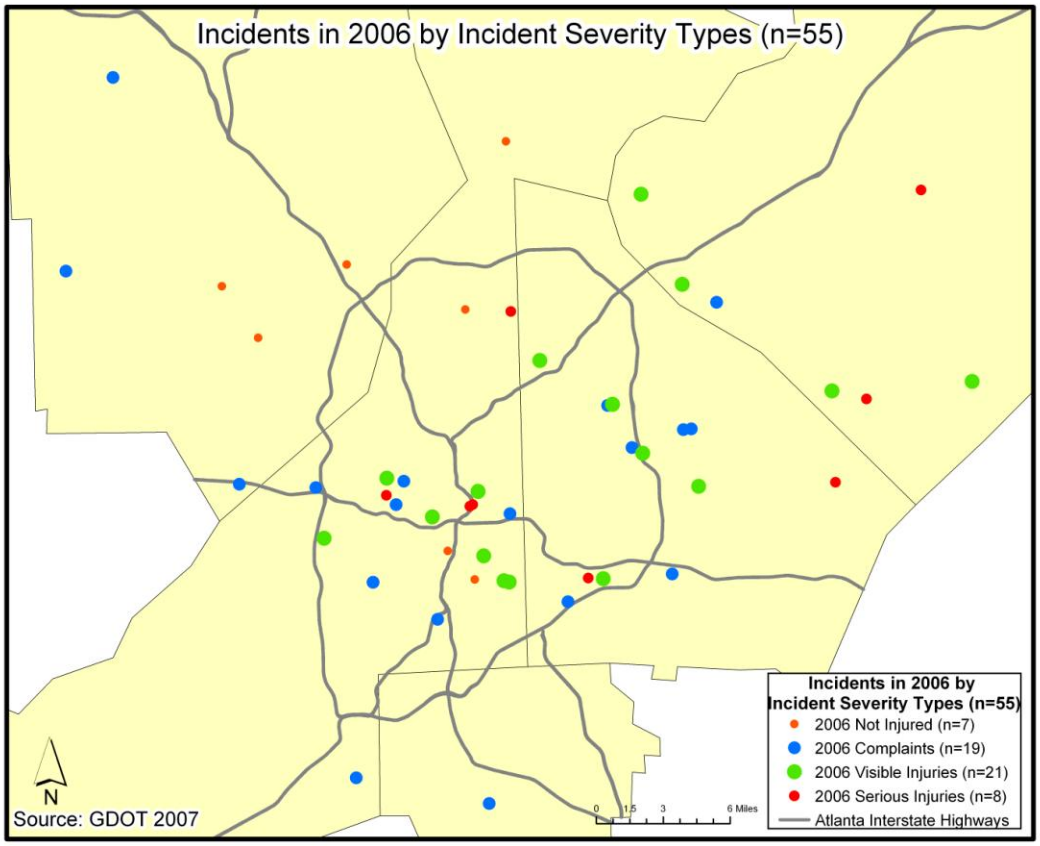
AK. Incidents in 2003 by severity types



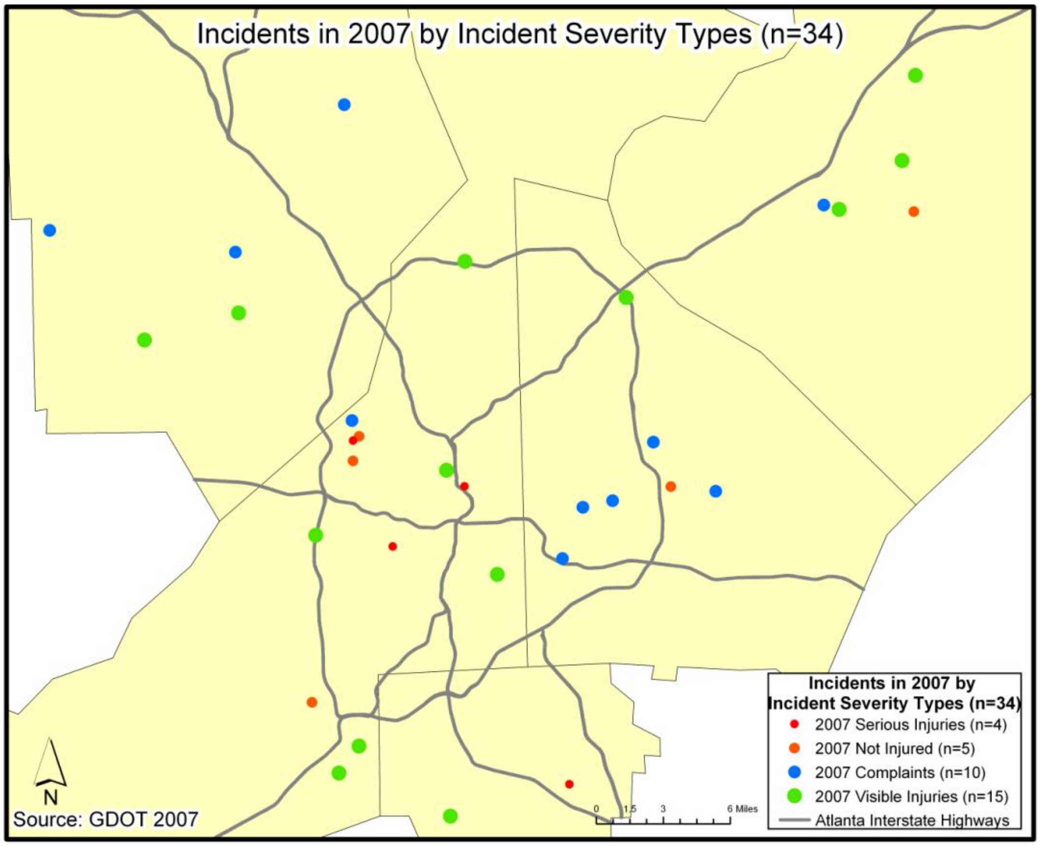
AL. Incidents in 2004 by severity types



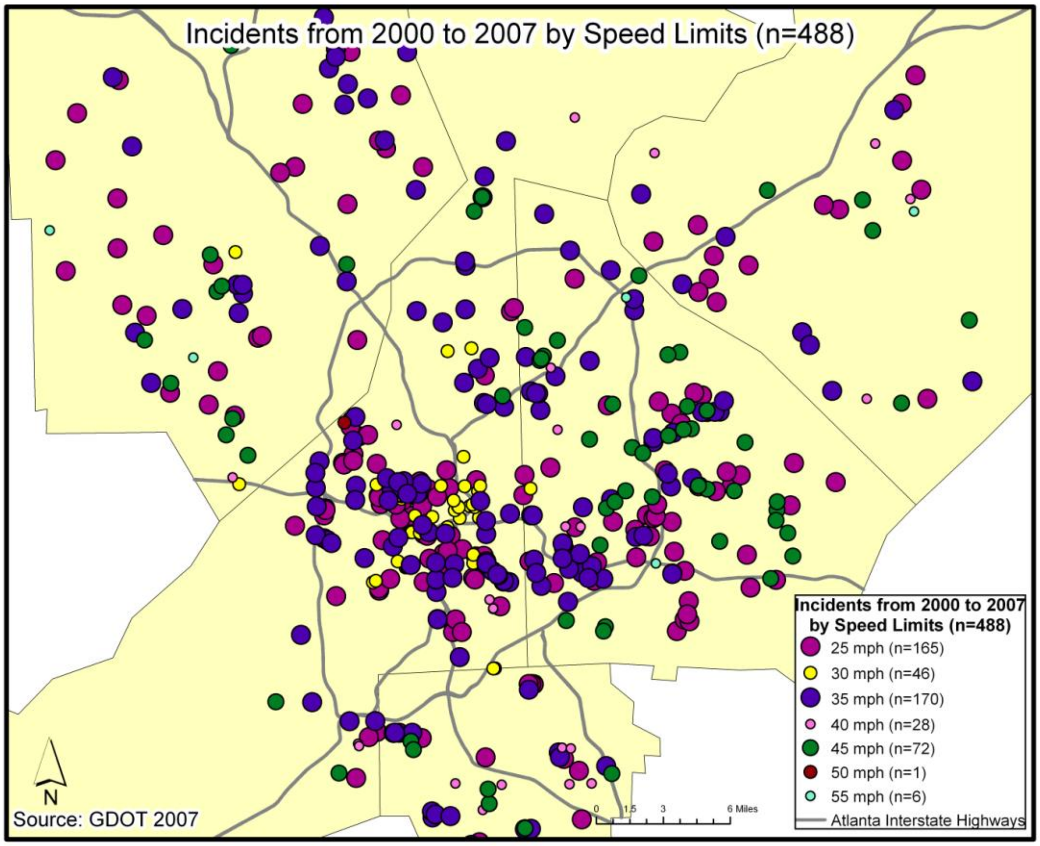
AM. Incidents in 2005 by severity types



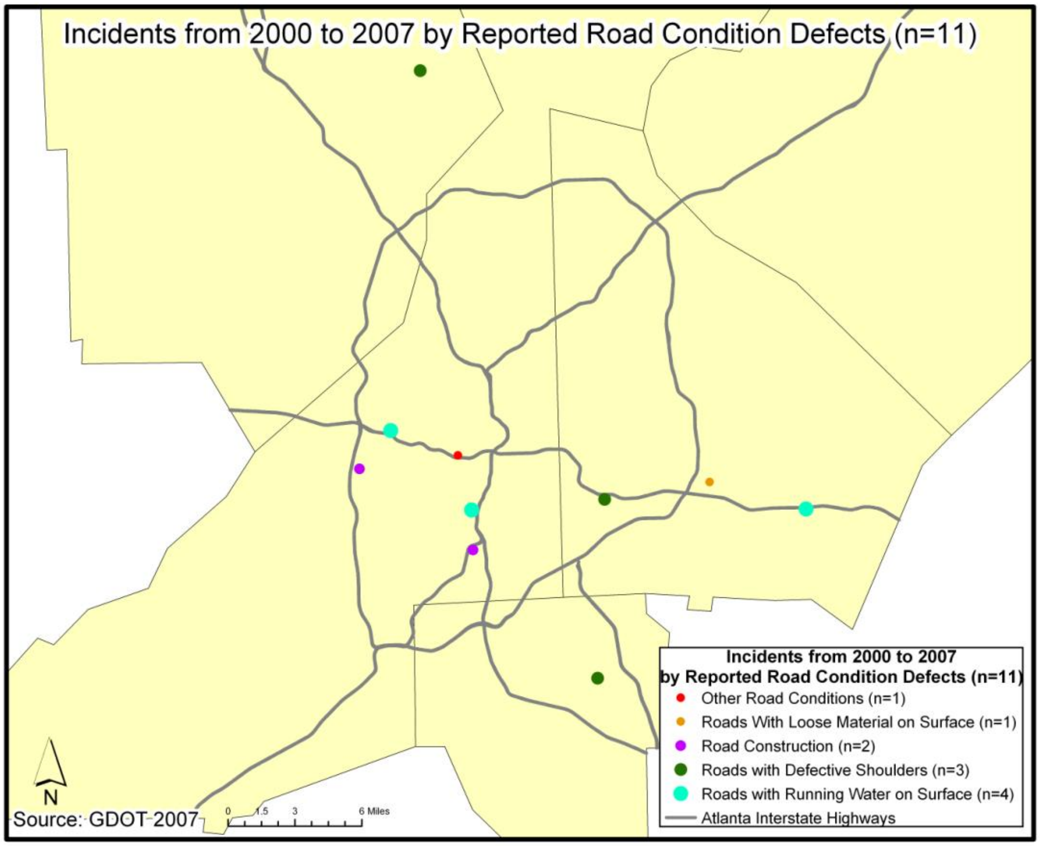
AN. Incidents in 2006 by severity types



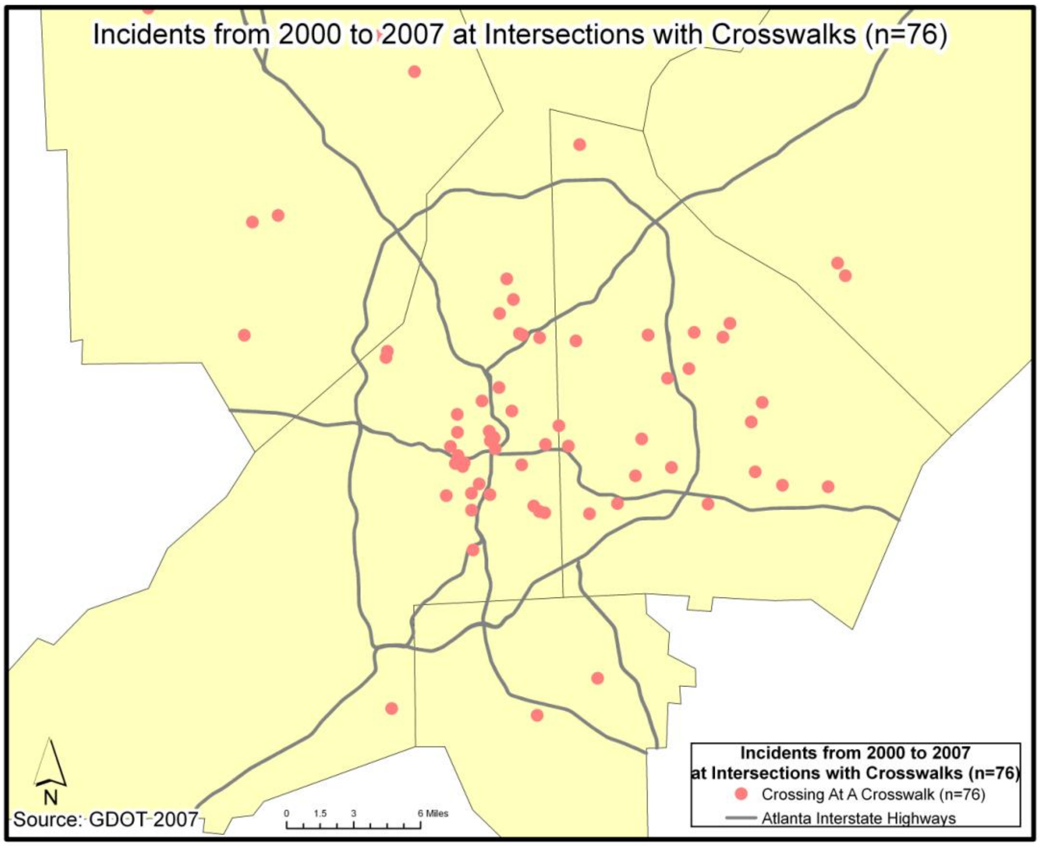
AO. Incidents in 2007 by severity types



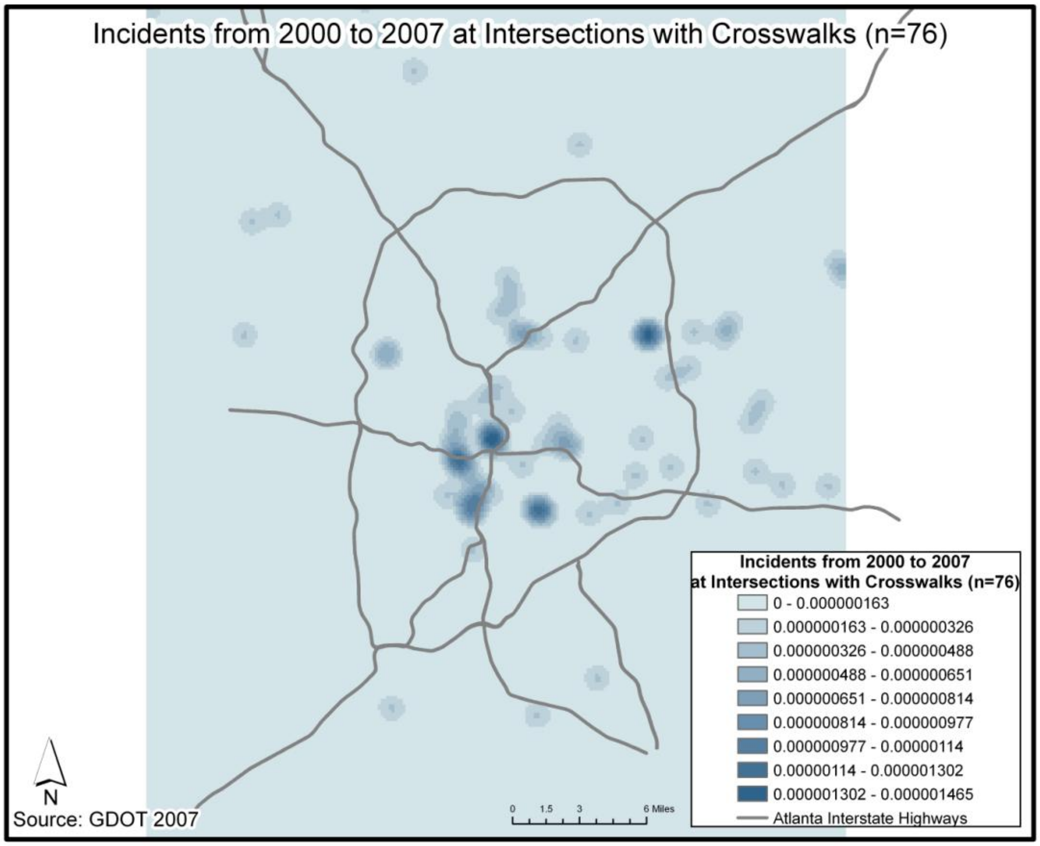
AP. Incidents from 2000 to 2007 by speed limits



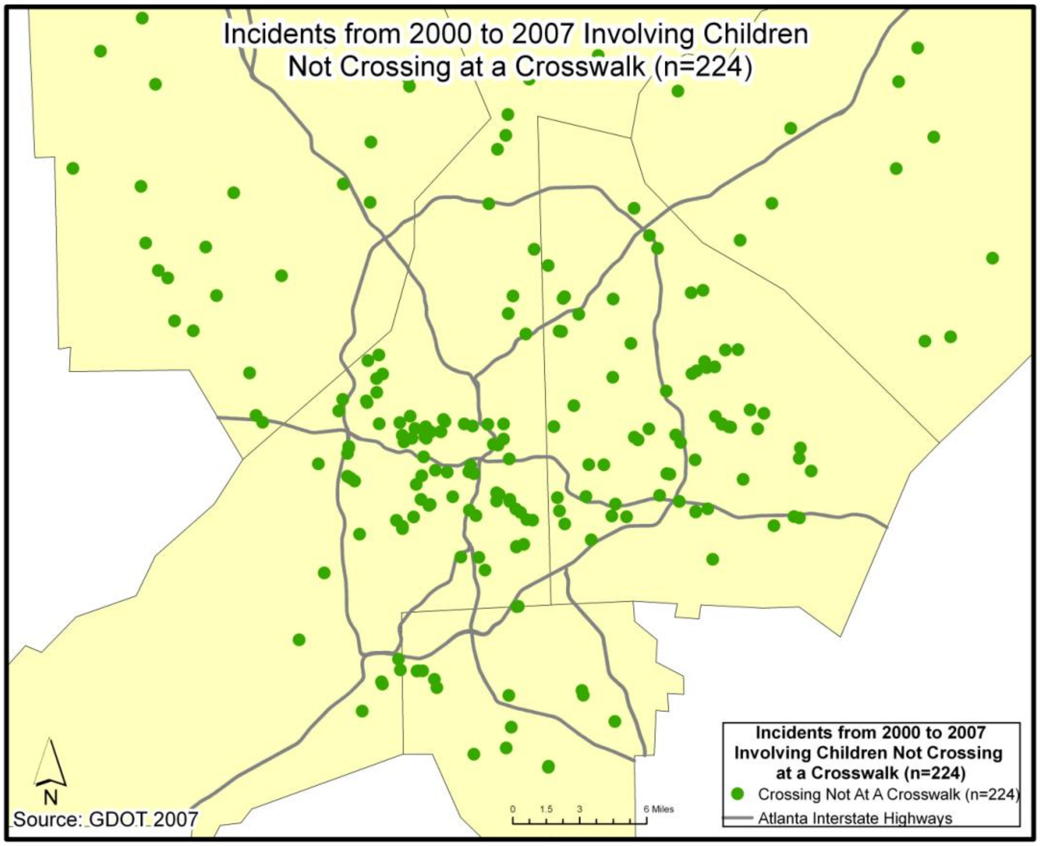
AQ. Incidents from 2000 to 2007 with reported road condition defects



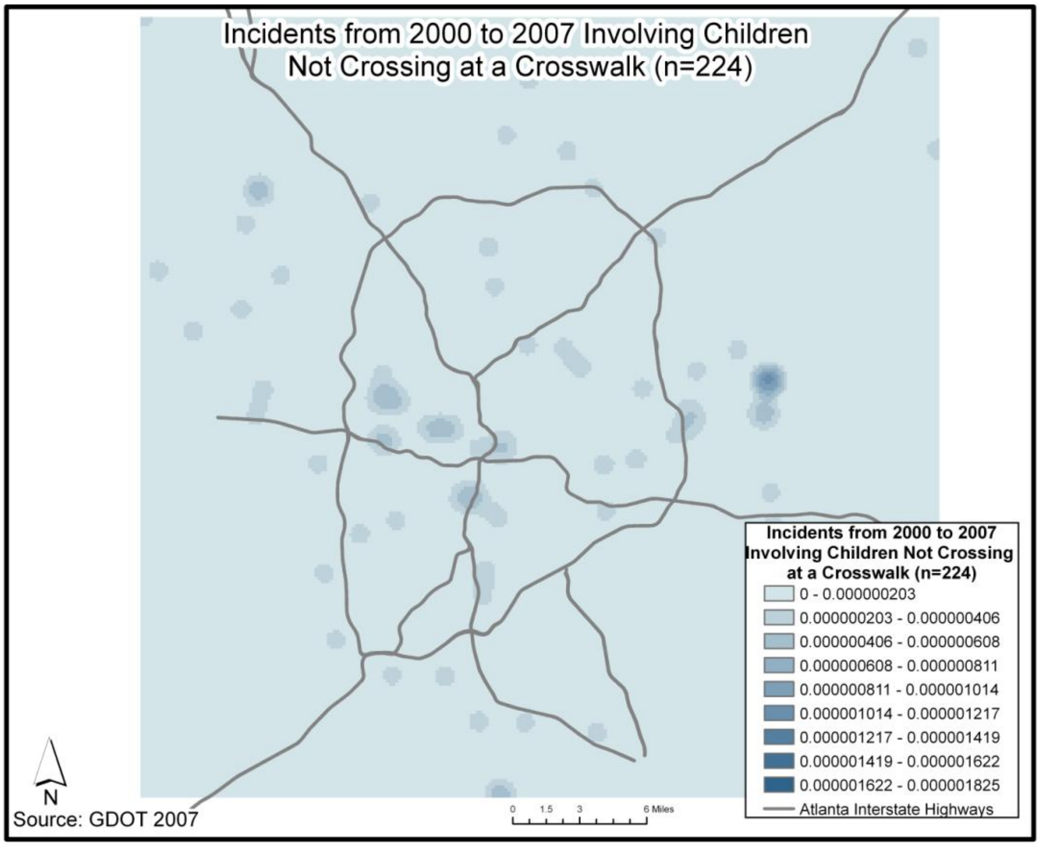
AR. Incidents from 2000 to 2007 at intersections with crosswalks.



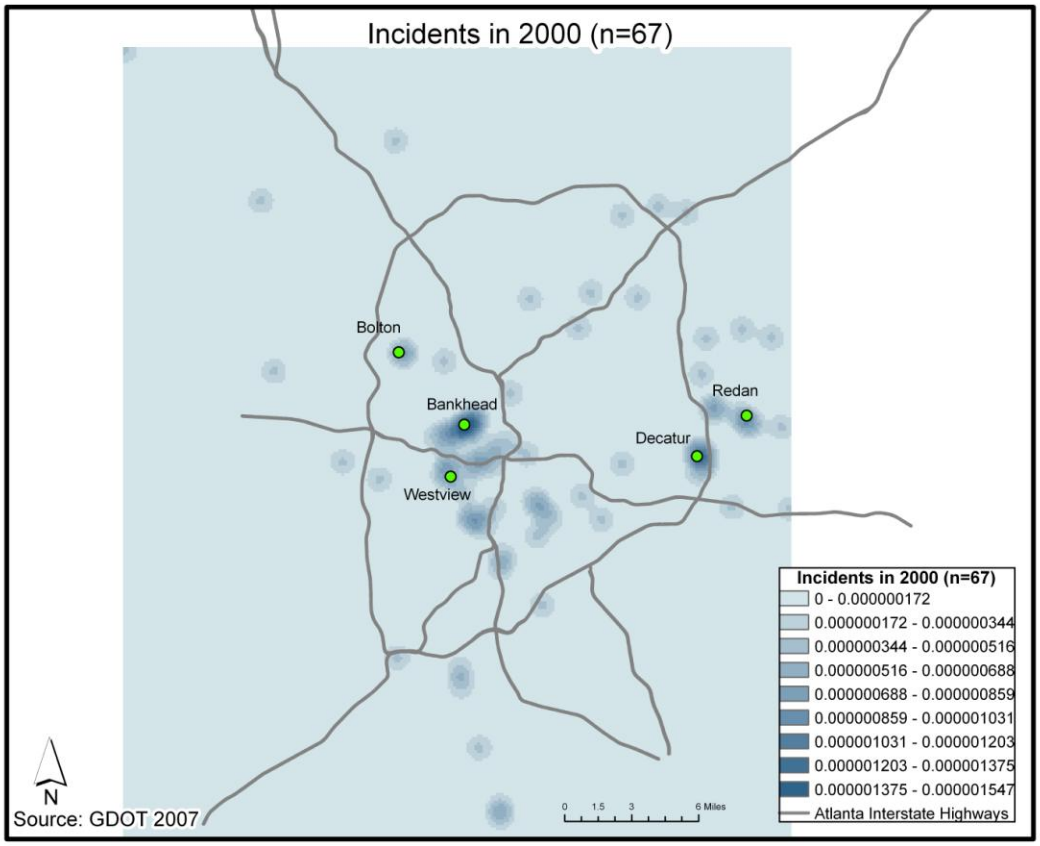
AS. **Incidents from 2000 to 2007 at intersections with crosswalks. Darker shading indicates higher concentration of incidents per square mile.**



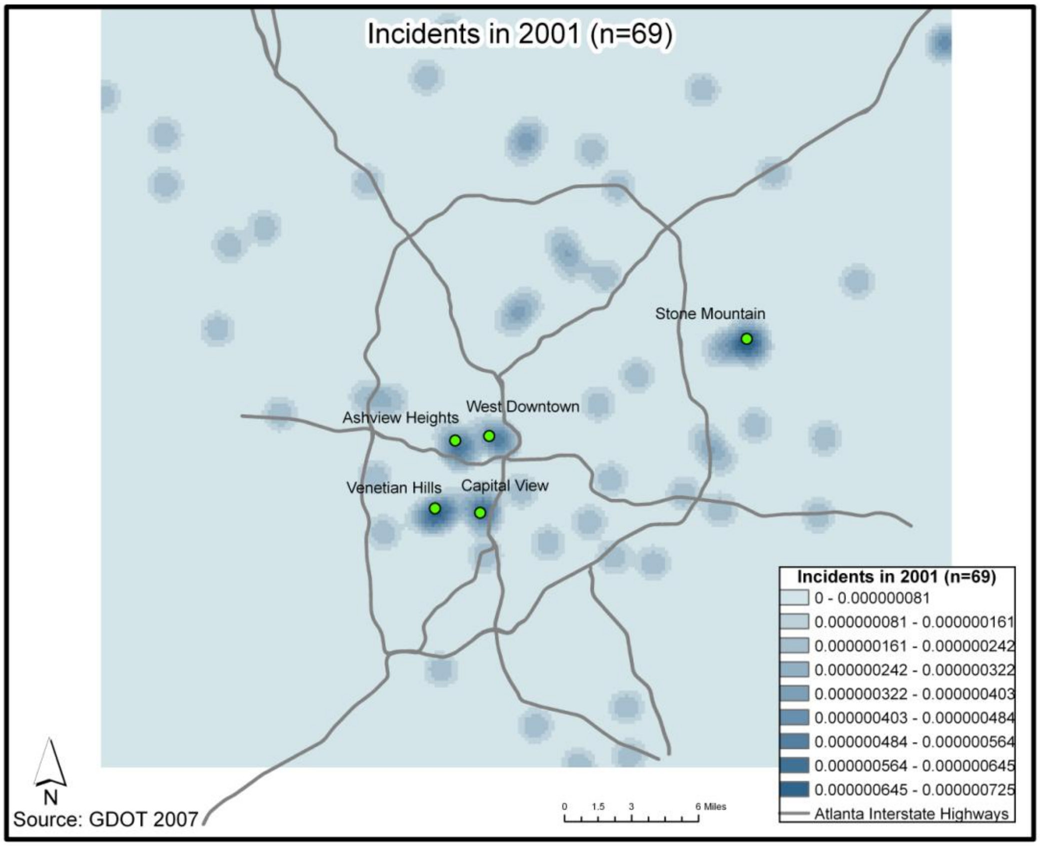
AT. Incidents from 2000 to 2007 involving children not crossing at a crosswalk



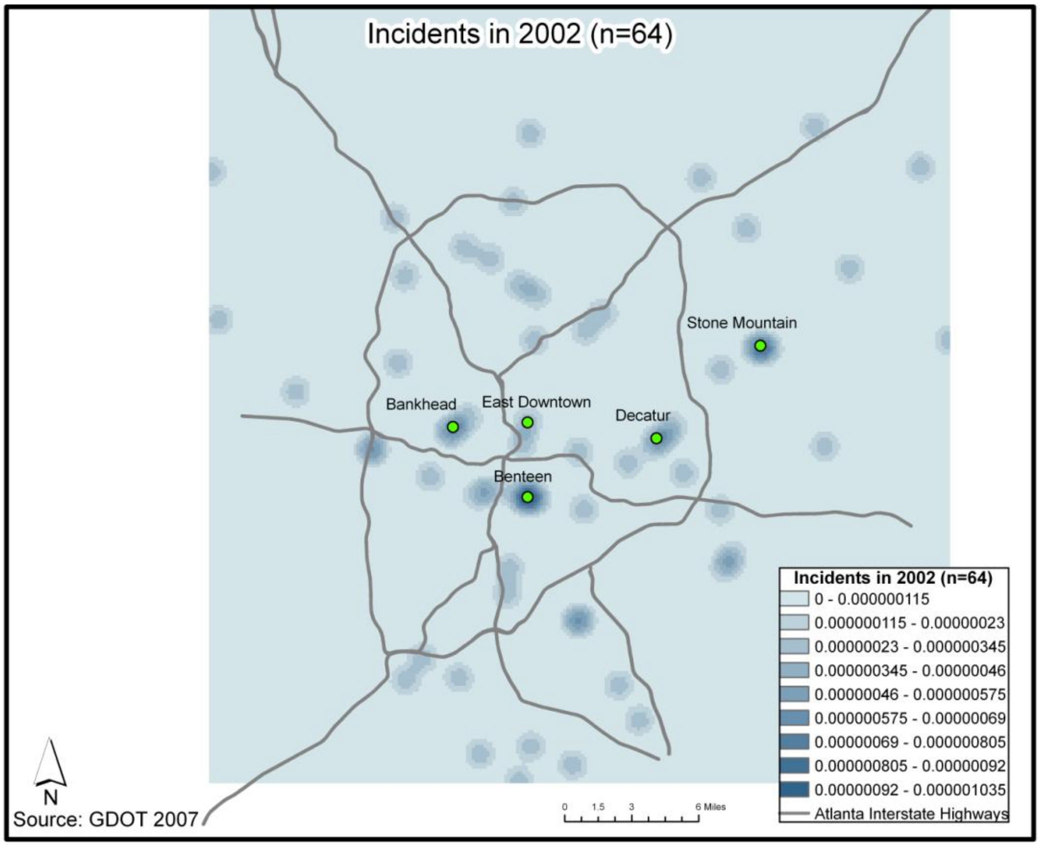
AU. Kernel density map of incidents from 2000 to 2007 involving children not crossing at a crosswalk. Darker shading indicates higher concentration of incidents per square mile.



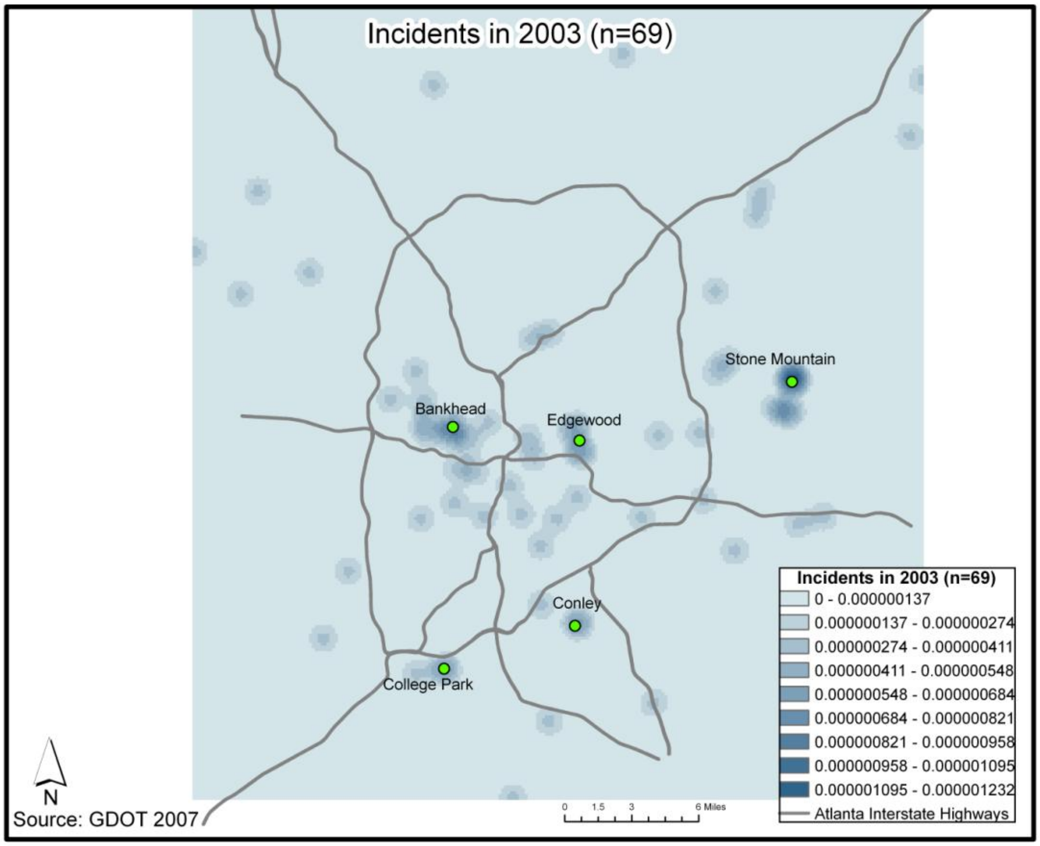
AV. Kernel density map of incidents in 2000. Darker shading indicates higher concentration of incidents per square mile.



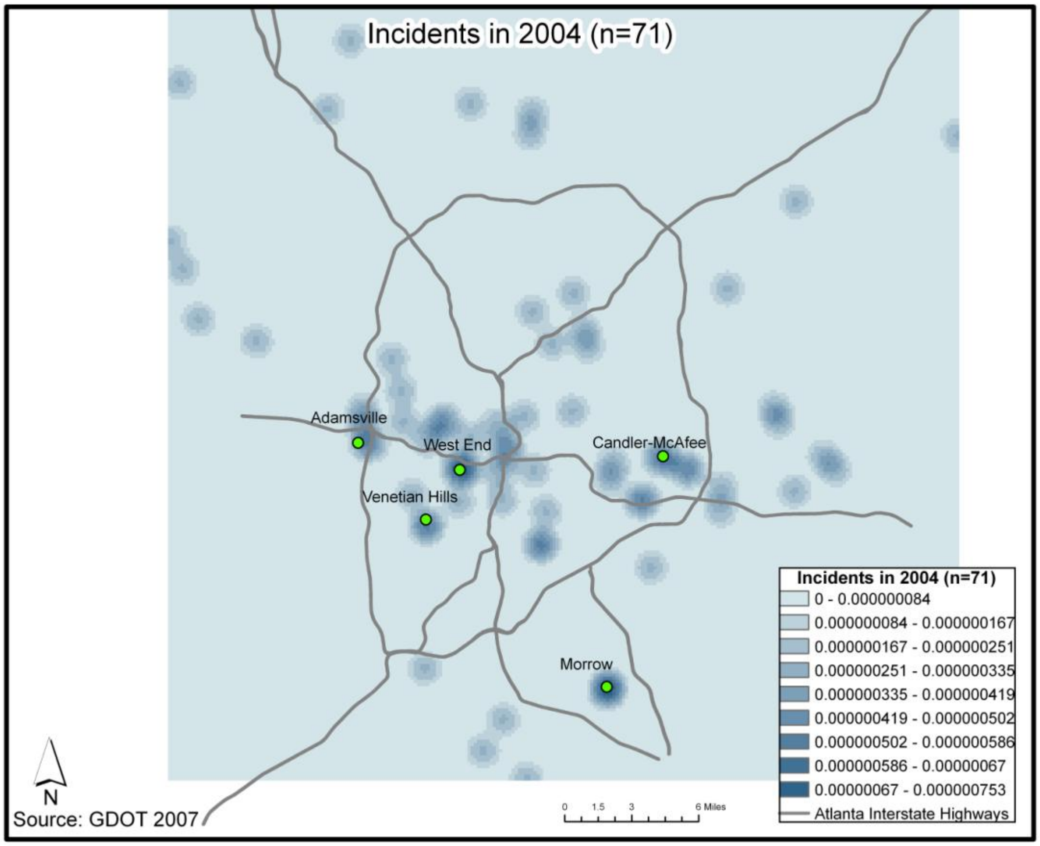
AW. Kernel density map of incidents in 2001. Darker shading indicates higher concentration of incidents per square mile.



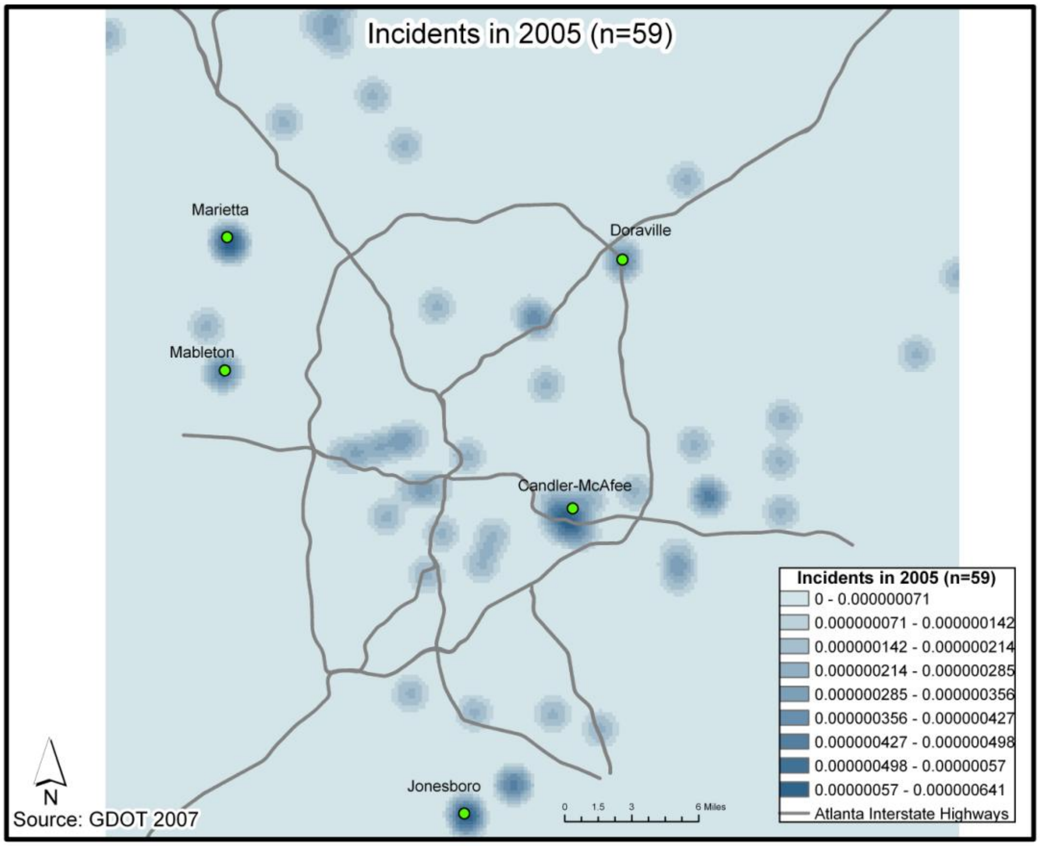
AX. Kernel density map of incidents in 2002. Darker shading indicates higher concentration of incidents per square mile.



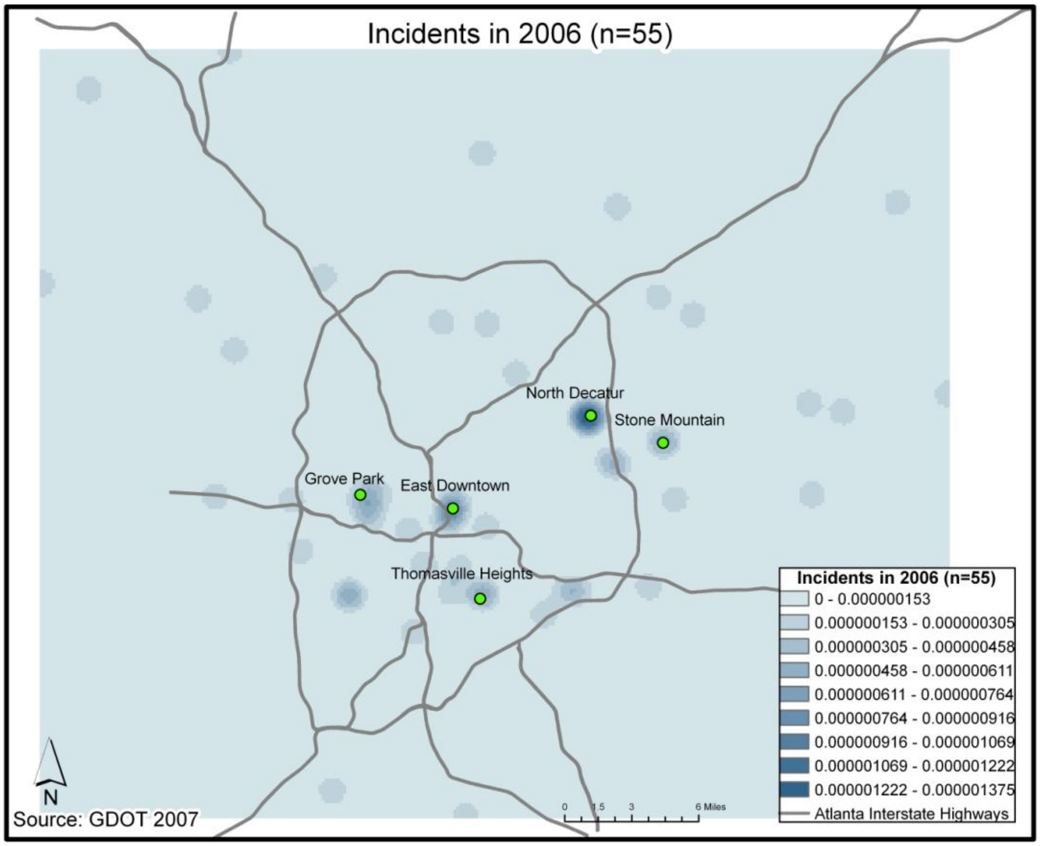
AY. Kernel density map of incidents in 2003. Darker shading indicates higher concentration of incidents per square mile.



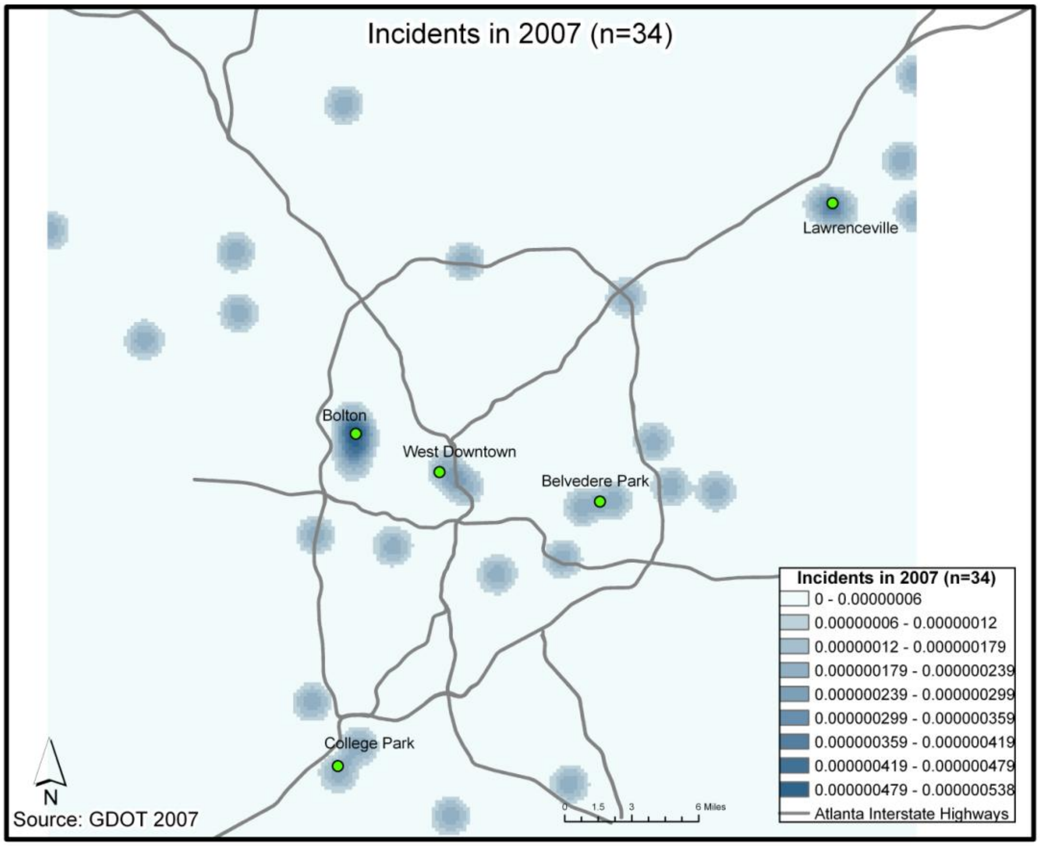
AZ. Kernel density map of incidents in 2004. Darker shading indicates a higher concentration of incidents per square mile.



BA. Kernel density map of incidents in 2005. Darker shading indicates a higher concentration of incidents per square mile.



BB. Kernel density map of incidents in 2006. Darker shading indicates a higher concentration of incidents per square mile.



BC. Kernel density map of incidents in 2007. Darker shading indicates a higher concentration of incidents per square mile.

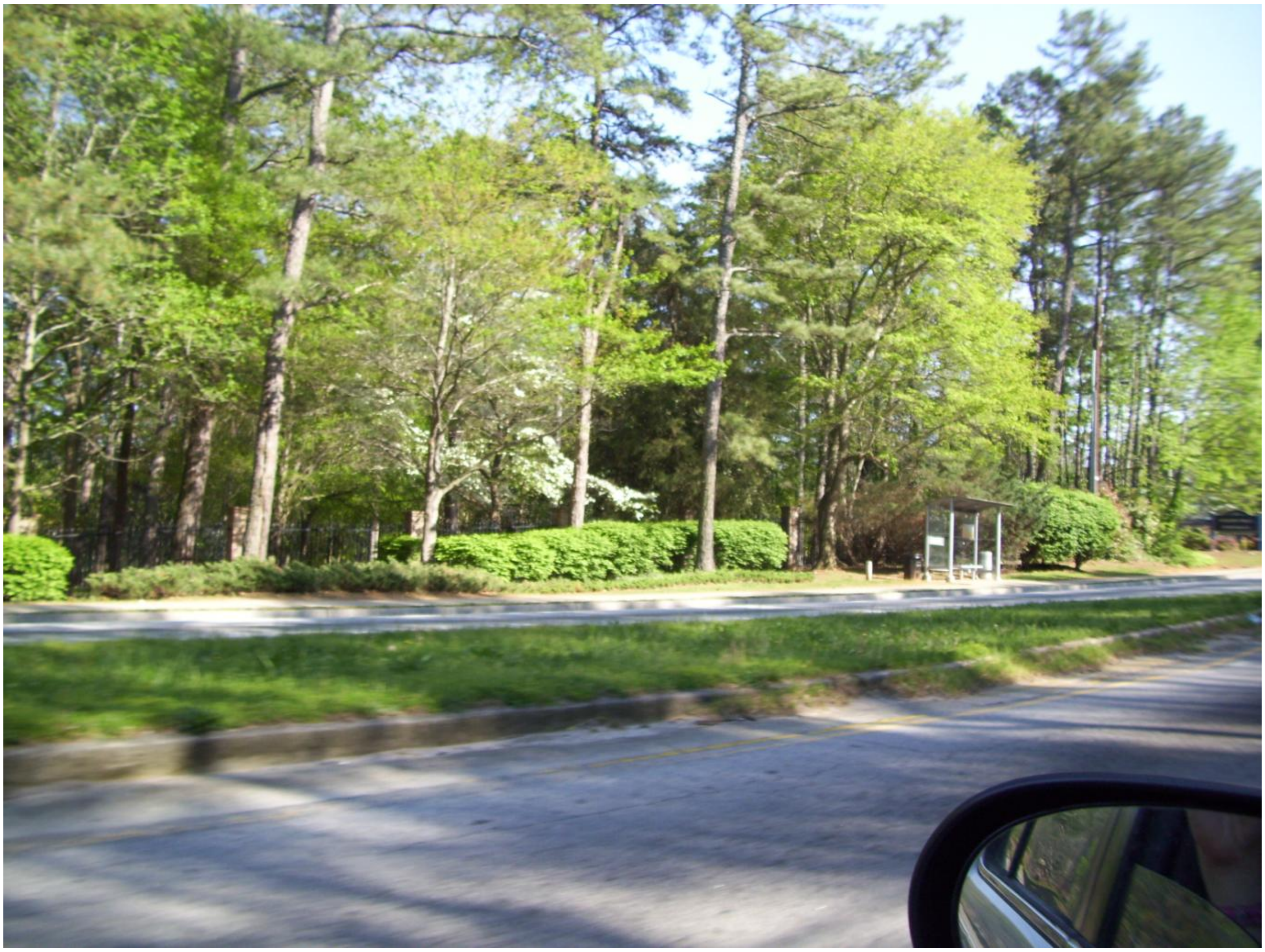
Five Densest Clustering of Incidents

	1	2	3	4	5
2000	Bankhead	Decatur	Redan	Westview	Bolton
2001	Stone Mountain	Ashview Heights	West Downtown	Venetian Hills	Capital View
2002	Stone Mountain	Benteen	Bankhead	Decatur	East Downtown
2003	Stone Mountain	Bankhead	Edgewood	Conley	College Park
2004	West End	Morrow	Adamsville	Venetian Hills	Candler-McAfee
2005	Marietta	Candler-McAfee	Jonesboro	Doraville	Mabelton
2006	North Decatur	East Downtown	Grove Park	Thomasville Heights	Stone Mountain
2007	Bolton	Lawrenceville	West Downtown	Belvedere Park	College Park

BD. Table displaying five areas with densest clustering of incidents according to kernel density analyses.

BE. Image of Stone Mountain and unincorporated Dekalb County: Intersection of N. Hairstron Road and E. Ponce De Leon Avenue with crosswalks.

BF. Image of Stone Mountain and unincorporated Dekalb County: Intersection of N. Hairstron Road and Central Drive with pedestrians crossing before crosswalk.



BG. Image of Stone Mountain and unincorporated Dekalb County: N. Hairstron Road with median and MARTA bus stop.

BH. **Image of Stone Mountain and unincorporated Dekalb County: N. Hairstron Road with 45 mph sign,median and pedestrian crossing the street at mid-block location.**

BI. Image of Stone Mountain and unincorporated Dekalb County: construction projects on Memorial Drive.

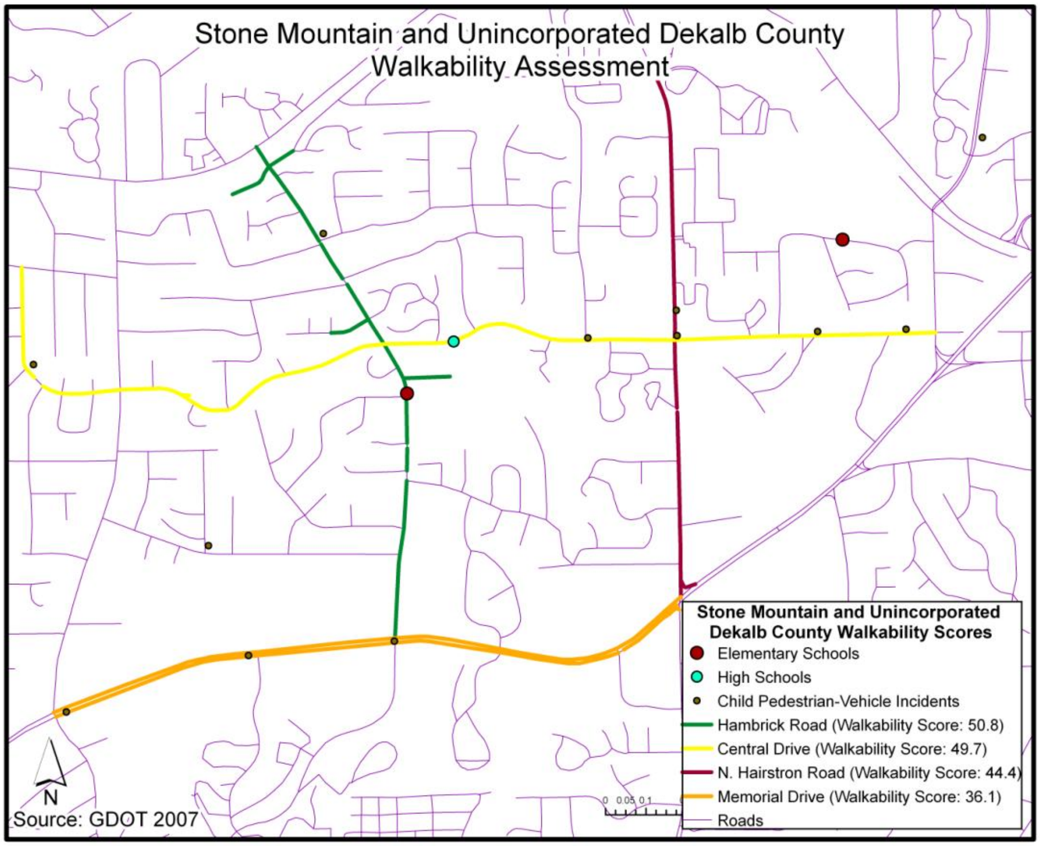
BJ. Image of Stone Mountain and unincorporated Dekalb County: Memorial Drive MARTA bus stop.

BK. Image of Stone Mountain and unincorporated Dekalb County: Hambrick Road with “25 mph when flashing” sign located above road.

BL. Image of Stone Mountain and unincorporated Dekalb County: Hambrick Elementary School located on Hambrick Road with crosswalk.

BM. Image of Stone Mountain and unincorporated Dekalb County: Central Drive in front of Stone Mountain High School with 35 mph sign near bend in the road.

BN. Image of Stone Mountain and unincorporated Dekalb County: Central Drive in front of Stone Mountain High School with crosswalk at top of hill in front of school entrance.



BO. Map of Stone Mountain and unincorporated Dekalb County area illustrating results from walkability assessment with school and incident locations over eight-year study period.